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The Journal of HEREDITY

HARVEST TIME IN A FIELD-CROP NURSERY

Willet Martin Hays—Pioneer Breeder

Identical Twins in Cattle

Inheritance of Immunity

VOLUME 20 NOVEMBER, 1929 NUMBER 11

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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The

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W. M. Hays

WILLETT MARTIN HAYS

1859-1928

ANDREW BOSS
University of Minnesota

WILLETT MARTIN HAYS was born October 19, 1859, on a farm in Hardin County, Iowa. His parents, Silas Hays and Christena Lepley Hays, had migrated from Pennsylvania and established themselves on a homestead just prior to his birth. His father died when Willet was twelve years of age and he and an older brother became the active operators of the farm, supervised by the mother. In this way he gained at first hand an intimate knowledge of farm life and of the problems of those who farm. This was his first frontier.

From the common schools of Iowa to Oskaloosa College in 1878 marked the next step in the development of this potential scientist and educational statesman. He was a student at Oskaloosa until 1881. In 1882, fired with an ambition for further knowledge, he entered Drake University. Not satisfied with the nature of the instruction there offered and seeing opportunities for greater service in agricultural education and science, he entered Iowa State College in 1883. Throughout his school and college career he was under the necessity of finding his own support. This he did by assisting to operate the home farm, taking turn about with his brother, and by teaching country schools. He thus became not only acquainted with rural school problems but greatly interested in them, a fact which later enabled him to initiate a movement which greatly improved the quality of instruction for country boys and girls.

While a student at Iowa State College he was given part time employment on field crop experiments, thus gaining his first insight into scientific methods. Upon graduation from Iowa State College in 1885, he served for a year as an assistant to Seaman A. Knapp, then agriculturist at the Iowa State College and Experiment Station. It was at this period that agitation for experiment station work was at its height. As a consequence, Hays found himself in an atmosphere saturated with the idea of science in its application to agriculture and became thoroughly imbued with a desire to promote this type of research and education. Then followed a year of service, in 1887, on the editorial staff of the *Orange Judd Farmer*, published in Chicago, where his vision was widened and valuable contacts were made with men high in national and agricultural affairs. This experience proved invaluable to him in after years when he himself began to produce for publication.

The Research Frontier

The passage of the Hatch Act in 1887 marked the advent of federally endowed experiment station work. The organization of state experiment stations proceeded rapidly and created a demand for men trained in science and in agriculture. Hays was drafted from the journalistic field when the Minnesota School of Agriculture was organized in 1888. He was appointed to an instructorship in agriculture in the school and served as assistant agriculturist in the Experiment Station under Director E. D. Porter.

Here he found two frontiers which strongly stimulated his imagination and ambition. His training and experience were such as to fit him for just such a situation. With characteristic foresight and vigor he began the attack. While a student assistant at Iowa State College he became interested in the growth of the corn plant as affected by cultivation. This led to a study of the root

habits of corn and other plants and to a new understanding of the principles involved in tillage. Feeling that the subject had not been exhaustively treated, new studies were initiated at the Minnesota Experiment Station,[1-3] and later continued at the North Dakota station.[4] Hic contributions to these subjects proved stimulating to workers in other stations and led to definite improvements in tillage operations and in methods of crop production.

As early as 1890 Hays conceived the idea that *"There are Shakespeares among plants."* Recognizing the individual plant as the unit of improvement and being cognizant of the effects of hybridization, he set about finding ways to breed and test large numbers of plants so that he might "find the Shakespeares." From a few rod squares of timothy in 1890, where the plants were treated individually, to a crop nursery of several acres with millions of individual plants of all classes of crops by 1900, marked the progress of his efforts. From individual plants a foot apart each way, to centgeners* of plants four inches apart each way and planted by a machine of his own design, indicates the ingenuity of the man in accomplishing the desired objective. Extensive travels, visits to experiment stations and a trip to Europe in 1899 gave him a wide acquaintance with other plant breeders and with methods employed elsewhere. His contributions to plant breeding literature were numerous, forceful, and stimulating.[5,11]. As a result of the plant breeding investigations several new varieties of field crops were originated which were widely distributed and became commercially valuable. Among these were Minnesota No. 13 corn, still widely grown; Minnesota No. 169 Bluestem wheat; Primost, or Minnesota No. 25 flax; Minnesota No. 105 barley, and Minnesota Nos. 281 and 295, two introduced varieties of oats. No less important to the agriculture of the Northwest was his discovery, in conjunction with the writer, of a winter-hardy variety of alfalfa. This variety had been introduced in Carver County by a German immigrant, Wendelin Grimm, in 1857. Through a process of rigorous natural selection the stock had been preserved and unconsciously built up by Mr. Grimm into a highly cold resistant strain. This strain came to the attention of Hays. He became convinced that *"here is a Shakespeare among the alfalfas. It ought to be propagated."* As a conequence, Grimm alfalfa became a recognized variety and is now the standard recommended variety wherever cold resistance is a factor in successful alfalfa growing.

Convinced through successful experience in breeding cereals that here was the way to improvement in other plants, Hays early urged his colleague in Horticulture, Professor S. B. Green, to initiate work in fruit breeding. A start was made at University Farm, but soil and environment were not favorable and the available land was limited. On the advice of Hays, land was sought for a fruit breeding farm in the vicinity of Lake Minnetonka, where a farm of 78 acres was purchased. Other land was later added and the fruit-breeding farm consisting of 118 acres became and has continued a prolific source of new and important fruit varieties. It was thus that he not only worked his own frontier but stimulated others into new fields of related research.

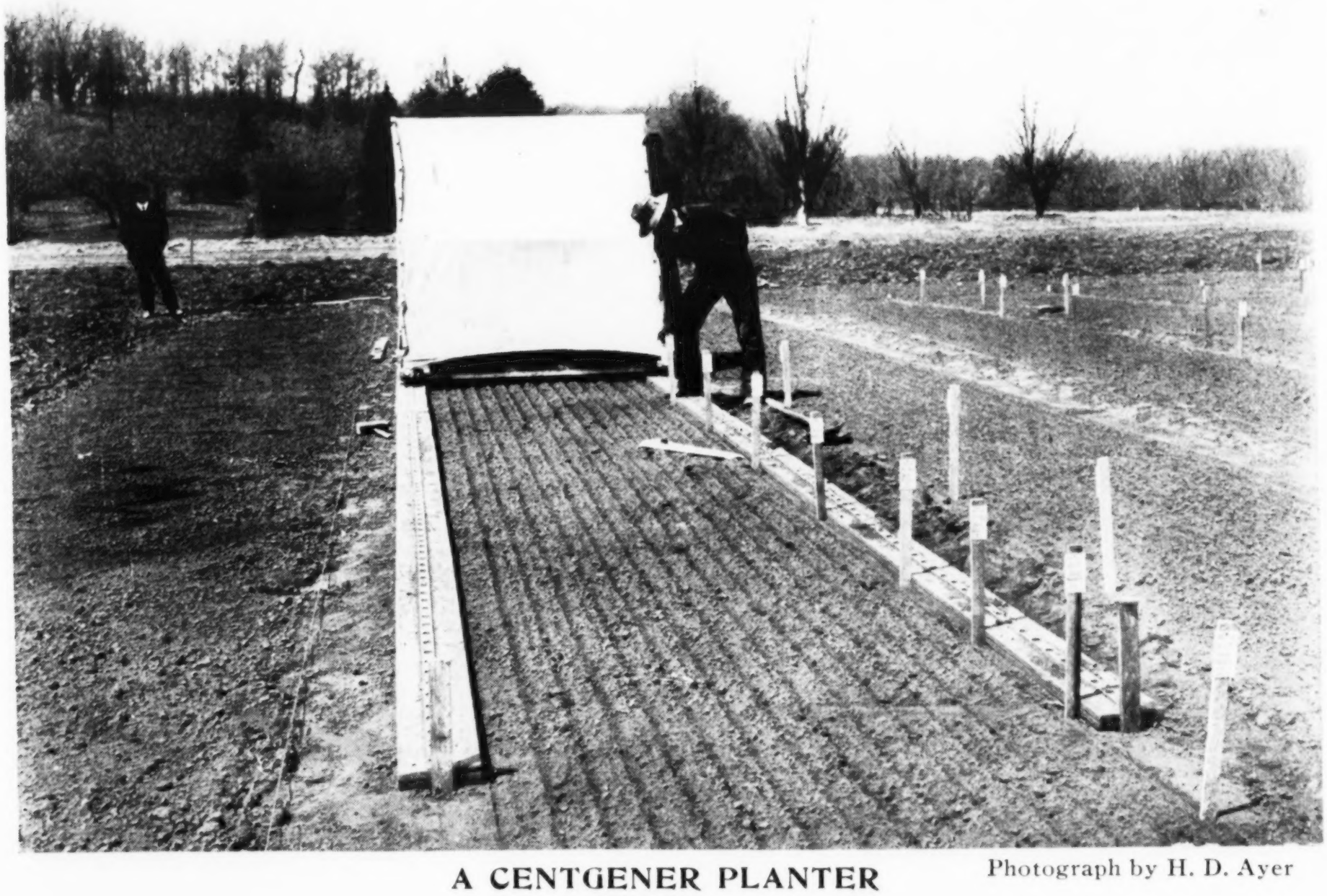
In his research activities Hays was cooperatively minded. While many of the scientists of his day were individualists, jealous of their researches and in a large measure secretive as to their

*A word of Hays' coinage signifying 100 plants of a generation. Hays was the first breeder to appreciate that the best measure of the quality of an individual was to be found in the characteristics of its progeny. The appreciation of this point led to the centgener system of planting, where 100 offspring of a single individual are grown to determine the merits of the selected parent.—*Ed.*

PROSPECTIVE PARENTS OF PLANT SHAKESPEARES

Figure 1

Professor Hays gave close personal attention to the selection of foundation stocks but with the reservation that they must make good on production records or be thrown out. The two views show Hays preparing the florets of pollination and selecting superior individuals for foundation strains. The technique of pollination and selection was developed a step at a time and results carefully noted and compared. Photos 1904.



A CENTGENER PLANTER Photograph by H. D. Ayer

Figure 2

A machine and track developed by Professor Hays and associates for planting grain at even spaces and at uniform depth—an important step in mass production of individual plants. It is covered to prevent wind from blowing light seeds out of seed cups. Each stake marked a centgener planted. The card label on the stake carried the centgener number, the stock and the key to the ancestry of the stock with the date of origin. The soil at the left has been prepared for the next bed. Photo 1904.

methods and objectives, he sought advice on every side. His researches and his methods were an open book to all. If there were suggestions in them, anyone was welcome to use them. He was quick to adopt the ideas of others, but giving them credit. While he sometimes antagonized others by his aggressiveness and vision, he usually gave more than he received. Early in his attempts to develop plant breeding methods be secured the cooperation of agronomists in the neighboring states and in the United States Department of Agriculture. Exchanges of stocks were made, conferences were held and Hays frequently visited the other experiment stations and the Federal Department that he might have the benefit of discussion with others working in similar lines. Investigators in the spring wheat states were drawn into an informal cooperative agreement for the promotion of plant breeding and for the use of better methods of procedure.

Recognizing the influence of environment in effecting changes in plants and in bringing out new adaptations, Hays early established the practice of enlisting the cooperation of farmers in testing varieties and in studying cropping practices. Finding it difficult to control the field operations under such circumstances, he advocated the establishment of branch stations and in spite of the indifference, and even of active opposition by the University administration, he succeeded in persuading the state

AN INFORMAL CLASS IN PLANT BREEDING

Figure 3

Evening seminars in plant breeding were a common occurence. With the pressure of the day's work over, there was freedom from restraint and abundant opportunity for discussion of natural laws and of methods and technique. Among those who attended the classes were many who later made important contributions to American agriculture.*

legislature, in 1895, to establish two branch stations, the North Central Sub-Station at Grand Rapids, Minnesota, in the timber area, and the Northwest Sub-Station at Crookston, in the heart of the Red River prairies. Later he obtained the transfer of the Indian school farm at Morris for a West Central Station, thus committing the Institution to the policy of branch stations. The five branch agricultural experiment stations of Minnesota stand as a monument to his wisdom and foresight.

Becoming concerned by the low returns from farming in the period between 1890 and 1900, Hays gave his attention to finding ways of improving farm incomes. After attempting to find a solution of the problem by improved cropping systems and studying net returns through labor and expense records on rotation plots at the North Dakota Experiment Station and at University Farm, St. Paul, he reached the conclusion that adequate data could be obtained only by securing farm business records of farms in operation. In company with the writer he visited farmers in the vicinity of Northfield in 1901, enlisted their cooperation and es-

*Some of those in the group who have since become prominent in agricultural research and education are:

A. D. Wilson, formerly director of Agricultural Extension, and member of the Board of Regents, University of Minnesota; John Thompson, Des Moines, Iowa, Editor of the *Iowa Homestead;* E. C. Parker, Senior Marketing Specialist, United States Department of Agriculture; Beyer Aune, Superintendent of the Bellefourche Experiment Farm, United States Department of Agriculture; Andrew Boss, Director of Agricultural Experiment Station, University of Minnesota; J. G. Haney, Superintendent of the International Harvester Company Farm, Grand Forks, North Dakota; C. P. Bull, Assistant, Minnesota State Department of Agriculture.

Photograph by H. D. Ayer

THE SEARCH FOR PLANT SHAKESPEARES

Figure 5

Professor Hays (center) and associates making plant selections at harvest time (in 1899). Much attention was given to individual plant notes and to centgener behavior. Special "harvesting envelopes" were developed, one of which may be seen on the knee of the second figure from the left.

tablished the first Farm Business Analysis, or so-called Cost of Production Route, in the United States. Similar routes were established in southwestern Minnesota and in the Red River Valley with the thought that these would give a comprehensive picture of the farming industry of Minnesota and furnish information that would be basic in reorganizing methods of management. Cooperative relations were established with the Bureau of Statistics of the United States Department of Agriculture, thus gaining both technical and financial assistance. Hays interested others in the project and the investigations widened and gained new followers. Several other states began investigations of the business side of farming, thus laying the foundation for the establishment of the Office of Farm Management in the United States Department of Agriculture and leading to the development of the subject-matter field of farm economics. That he saw the problem clearly is indicated by the first publications resulting from the investigation[12,13]. The comprehensiveness of the plans laid, the scope and vigor of the attack and the persistence with which it was followed up were characteristic of the statesmanlike methods employed in his research activities.

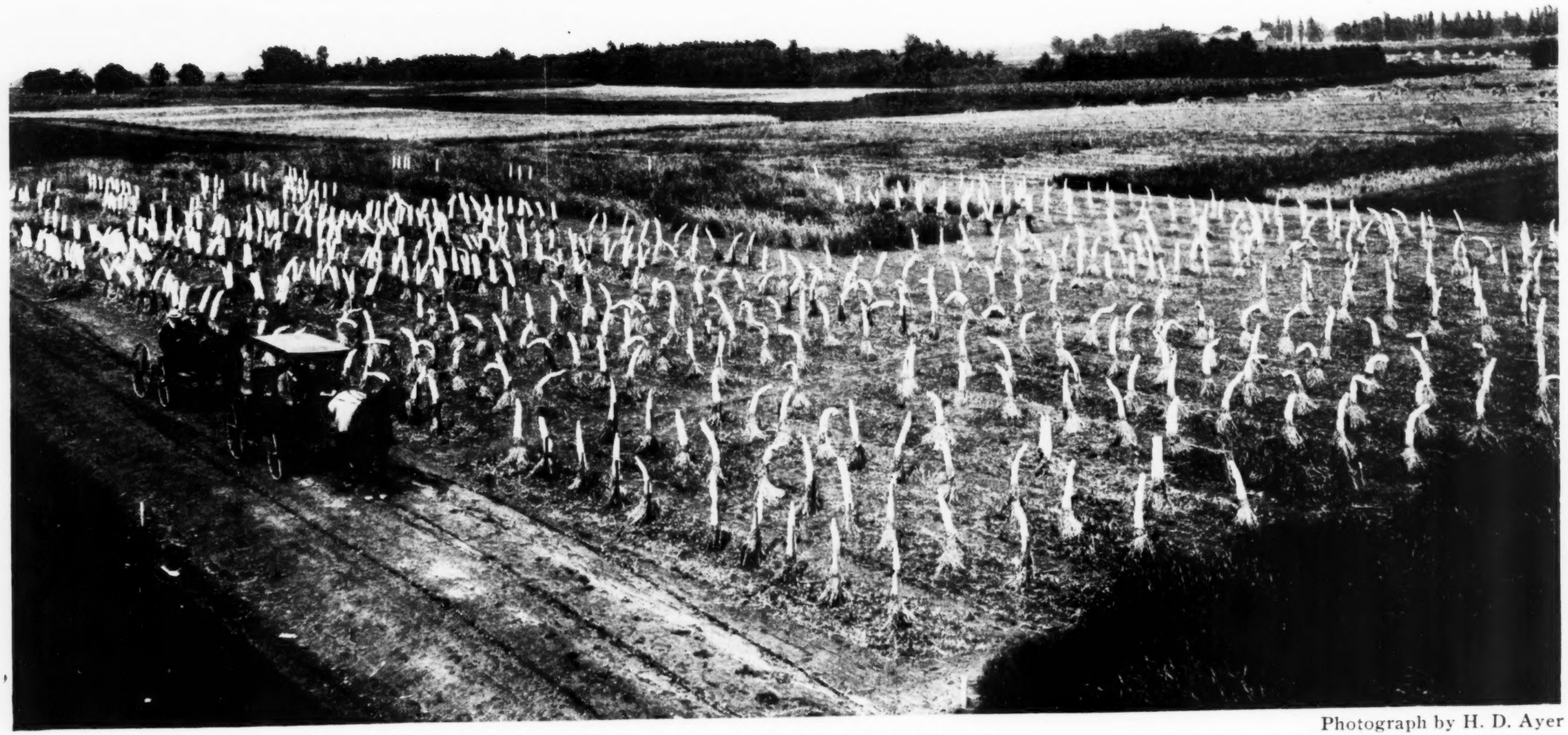
The Educational Frontier

In his life as a boy on an Iowa homestead; in his struggle to secure an education, and in his experience as a country school teacher, Hays had gained a first-hand knowledge of country life and its manifold educational problems. This knowledge proved invaluable as a background for his services in the then recently established, secondary school of agriculture of the University of Minnesota, and later in his endeavor to carry suitable education to the masses in agriculture. With his mind centered on the problems of the farm, he developed the subject matter of his teaching courses with a view to easing the burdens of the future farmers, to stimulating their interest in plant and animal life, and to putting them in harmony with their environment and surroundings. Nor were cultural values overlooked. Himself convinced that there "is as much culture in agriculture as in pure culture," he consistently advocated the study of nature, science, and art in relation to the farm and farm life. New subject-matter courses were developed as experience indicated a possibility for a more constructive curriculum or better teaching methods. His aggressiveness in these lines led to the initiation in the Minnesota School of Agriculture of courses in "Dressing and Curing Farm Meats," "Handling Grain and Machinery," "Farm Development," and "Farm Planning and Management." These have since become standard courses in many agricultural colleges.

Hays early became an advocate of agricultural instruction in the rural and grade schools and of cultural vocational education. In support of these movements he gave freely of his time and energy, writing magazine articles, preparing lessons for teachers, and assisting in organizing new projects. A series of "agricultural readers for rural schools" was outlined. The writing was started but because of pressure of official duties, never completed. Out of these activities grew the idea of the consolidated rural school with graded lessons, increased facilities and teachers "prepared to give culture in agriculture to the children of the countryside." His vision included a linkage of this kind of a consolidated rural school with the state secondary or agricultural high schools and the state agricultural college, all "articulating with the University of farm life."

That his interest in these matters was more than local is indicated by his authorship of the Nelson Amendment passed by Congress in 1907, and providing $25,000 annually to each of the state agricultural and mechanical colleges. This amendment was designed to furnish funds for the more adequate

Professor Hays (center) and to centgener behavior. Special "harvesting envelopes" were developed, the left.



Photograph by H. D. Ayer

INSPECTING THE BREEDING FARM
Figure 4

Professor Hays and Hugo de Vries, the eminent Dutch scientist, inspecting the crop nursery at harvest time, 1904. Harvested centgeners, staked and wrapped with cloth for protection, are shown in the foreground and at the right. An increase field is shown in the background. Progenies that proved superior in centgener trials were given a more extensive trial in the increase fields, and if still considered promising were distributed for field trials by farmers.

"preparation of instructors for teaching the elements of agriculture and the mechanic arts." It is given further evidence by his leadership in the campaign for cultural-vocational education, 1906-1913. As technical author of the Doliver-Davis and Page-Wilson bills he led the fight for the cause that culminated in 1917 in the passage of the Smith-Hughes Act, now definitely a part of our public school system for providing agricultural education for the masses. Few men have contributed more than he in educational statesmanship, considering the conditions of his time and the obstacles to be overcome.

An account of his contributions to agricultural education would not be complete without a few words concerning his relations with his pupils. Though never a great lecturer, he was a great teacher. As an adviser, counsellor, and stimulator of thought he was at his best. Class room discourses were made interesting by his first hand knowledge of the subjects taught and by the practical applications made. By nature warm hearted and friendly he made his pupils his companions on intellectual adventures. He was tolerant of all of the attributes of student habits except "an idle mind." Work was his prescription for the blues and homesickness that often accompany student life. And he had the ability to find a use for the talents of his pupils, building them into his program for research and teaching.

Often, when not able to crowd into the ten hour day then in vogue all that he wanted to do, he would organize a morning or evening seminar for investigation and discussion. It was not an uncommon sight at University Farm to see the members of the seminar strolling among the field plots and through the plant breeding nursery during the dusky evening hours or in the early morning, when some particular phenomena were to be observed. Proverbially late to classes, oblivious of meal times and tardy in keeping appointments, he was at the forefront nevertheless in promoting new ideas, in initiating new methods and stimulating young men to give of their best to the cause of agriculture. Many of his former pupils have risen to places of prominence in agricultural science and education. These hold in high esteem the memory of his inspiration and devotion to their welfare. Other of his pupils who have pursued the common walks of life are likewise indebted to him for his guidance and the inspiration that has made clearer the path of duty and lighter the labors of their hands.

In Public Service

Hays took a keen interest in public affairs. Constructive in his views and disposition, mentally aggressive and alert, courageous, enthusiastic and persistent, he possessed qualities of leadership that counted for progress in many directions. His contributions to public welfare were more than can be enumerated in the space of this brief article.

While assistant agriculturist at the Minnesota Experiment Station, 1889-1890, he organized the station farm for systematic field plot tests. When the North Dakota Experiment Station was organized in 1891 he accepted the position of Agriculturist of the Experiment Station and Professor of Agriculture in the College. As Agriculturist he laid out the station farm for systematic crop rotations, planned the field-plot layout and established a field-crop breeding nursery, all of which features have been retained to the present. In the fall of 1893 he was called back to Minnesota as Professor of Agriculture in the College and Agriculturist in the Experiment Station. He was also made Vice-Chairman of the Experiment Station, under W. M. Liggett, then a member of the Board of Regents, as Chairman. It was at this time that he actively promoted the branch station idea which later became an accepted factor in agricultural research at Minnesota. He remained at Minnesota as Agricul-

HARVEST TIME IN THE FIELD-CROP NURSERY Photograph by H. D. Ayer

Figure 6

The field-crop nursery, at harvest time in 1904, as conducted by Professor Hays at the Minnesota Experiment Station. Fields in the background are sown to legumes and increase crops, in regular rotation in preparation for the nursery beds of the following year. Harvested centgeners are in the foreground. The centgener represents one of Hays' most important contributions to plant breeding: it consisted of 100 plants—the progeny of a single plant—the plants uniformly spaced four inches apart. Each harvested centgener is held in place by a stake driven in the ground and wrapped in a muslin cover to protect from birds

turist until June 1905, during which time he greatly expanded the crop breeding researches and initiated coöperative investigations between the five adjoining states of North and South Dakota, Nebraska, Iowa, and Wisconsin. In this way his influence was exerted over a large field of activities, resulting in greater standardization of method and joint analysis of research problems.

Finding in his experiment station investigations a great need for contact with enterprising farmers he promoted the organization of the Minnesota Field Crop Breeders' Association, serving as secretary from the date of its organization in 1903 until 1905 when he resigned from experiment station work. The Association continued, however, under his scheme of organization and has served an extremely useful purpose in introducing, standardizing and popularizing new varieties of field crops created in the plant breeding and testing laboratories of the Experiment Station.

The activities of Hays in plant breeding lines brought him in contact with many men prominent in animal breeding and production and he became much interested in their problems. This led to his taking the leadership in organizing so called breeding circuits where the progeny could be studied and where particularly potent sires could be maintained for service by exchange or rotation among members. On this basis a Milking-Shorthorn Breeding circuit was organized in Minnesota, choice sires were introduced and a foundation laid upon which has been built many of the good herds of the state. On similar lines, a Holstein breeding circuit was organized at New Salem, North Dakota, which has become famous as a center for breeding stock of high production and quality.

His interest in plant and animal breeding developed a need for technical knowledge of the processes of heredity. Always a great reader and traveler, he cultivated the acquaintance of specialists in these lines and studied closely their technique and methods. On a trip to Europe in 1899 he visited the plant breeding institutions of the Continent and of the British Isles, meeting those prominent in scientific research and gaining many new ideas directly applicable to the work in hand. He was one of the first to adopt the statistical method so far as it had been developed in his day and used "Quetelet's Curve" and "Mendel's Law" in illustrating the behavior of plant progenies.

Believing that there was great strength in organized effort and that more rapid progress could be made by concerted action, he gained the support of leading breeders and businessmen in founding the American Breeders Association in 1903. Later the name of this organization was changed to the American Genetic Association. Of this Association, Professor Hays served as Secretary from 1903 to 1913. During that period he founded the JOURNAL OF HEREDITY of which he was editor from 1910 to 1913. In the capacity of secretary of the American Genetic Association and editor of the JOURNAL OF HEREDITY, he made wide contacts among agricultural college and experiment station men and greatly stimulated interest in the subjects of heredity and genetics, which led eventually to the organization of departments of genetics in many institutions. While the methods and technique then used would be regarded as crude in the present day, it must be remembered that he was working on one of the frontiers of science and that much of the progress made has been due to the interest he aroused and the foundations he laid for advancement.

In 1905, Hays was offered an appointment as Assistant Secretary of the United States Department of Agriculture under James Wilson. Seeing in the call an opportunity for advancing some of the ideas so close to his heart,

he accepted the position in which he served until the close of Secretary Wilson's administration in 1913. As Assistant Secretary of Agriculture he introduced the "project" method of formulating work, which he had initiated in his experiment station work in Minnesota, and which has since been adopted officially by the Department of Agriculture in its relations with state experiment stations. He also brought about the reorganization of the Bureau of Crop Estimates and the organization of the Bureau of Public Roads and Rural Engineering. This was a subject in which he had long been interested, having written the Good Roads Amendment placed in the statutes of Minnesota.[14]

It was while Assistant Secretary of Agriculture that he most actively promoted legislation favorable to the establishment of secondary schools on the Minnesota plan. His ideal was an agricultural school for each congressional district, though he favored also provision for agricultural courses in city schools, believing that they held cultural values and that it was important that as many as possible receive the elements of an agricultural education. Due to his activities in this line several states adopted the district plan and have established schools of practical agriculture where farm boys and girls definitely prepare for farm operation and home making.

Hays also actively supported the idea of extension education for the masses. It is quite generally conceded that his efforts for the Dolliver-Davis and Page-Wilson bills led to the final form of the Smith-Hughes Act passed by Congress in 1917 and accepted by every state in the Union. Likewise, his earlier agitation for "carrying agricultural education to the farm" culminated in the Smith-Lever Act, the present basis of our comprehensive scheme of agricultural extension education.

When the Democratic Party came into power in 1913, under President Wilson, the administration of the Department of Agriculture by Secretary Wilson closed and Hays' service terminated. He was immediately requested to serve as agricultural adviser to the Minister of Agriculture of the Argentine Republic and to assist in organizing agricultural instruction in the University of Tucuman. He also assisted in the organization of research in the Argentine Experiment Station. This work was interrupted in 1914 by the outbreak of the World War and Hays returned to America. Overwork and worry over national affairs led to a break in health and he, with his family retired to a Pennsylvania farm in the hope of his recuperation. The hope was vain, however, as he never regained his health sufficiently to undertake public work. After fourteen years of impatient but always hopeful waiting for a return to health and activity he passed away at the home of his brother in Eldora, Iowa, on January 15, 1928.

An editorial in the St. Paul *Farmer* following his death is offered as an expression of the esteem in which his memory is held:

> "Willet M. Hays was an idealist and a dreamer of dreams as some of his critics once said. However, most of his dreams have since come true. He was one of the earliest advocates of vocational education, particularly the teaching of agriculture in the public schools. Unceasingly he worked for legislation that would make such education possible. He was an ardent advocate of visual education through the motion pictures and was scoffed at for his dreams. His "fooling with the breeding of plants" was barely tolerated until the great value of his work was proved. Anticipating the future by years is rarely popular to those who think chiefly of the present. Professor Hays thought of the things that should happen for the benefit of agriculture in future years and then burned out his energy to bring them about. His contribution to American agriculture was of utmost value."

Notwithstanding his extensive public service and heavy administrative duties, Hays was a productive research worker and virile writer. His production was increased because of his great ability to see clearly, plan wisely, judge accu-

rately, and to use the talents of his students and assistants in working out the details of his researches. In twenty-four years of active service in agricultural research and education he wrote or contributed to thirty Experiment Station bulletins, eight reports on important official investigations, three United States Department of Agriculture circulars, and eighteen magazine articles. He was the author also of a book on *Farm Development;* editor and leader in the preparation of another on *Rural School Agriculture,* and wrote freely for agricultural journals and the public press.

Few men of any generation have contributed more to the promotion of science in its application to agriculture or to the cause of vocational education for the masses. Unappreciated by many, misunderstood by others, some of them his associates and superior officers, and looked upon by still others as an agitator and radical, he will nevertheless go down in history as an intrepid frontiersman-scientist and a constructive agricultural statesman.

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The Chromosome Basis of Inheritance

DIE CYTOLOGISCHEN GRUNDLAGEN DER VERERBUNG: *By* KARL BELAR. Handbuch der Vererbungswissenshaft. Vol. 1, part 5. Pp. 412. 280 text figs. 2 plates. Subscription price, 40 R. M.; separately, 80 R. M. E. BAUER and M. HARTMANN, Berlin, 1928.

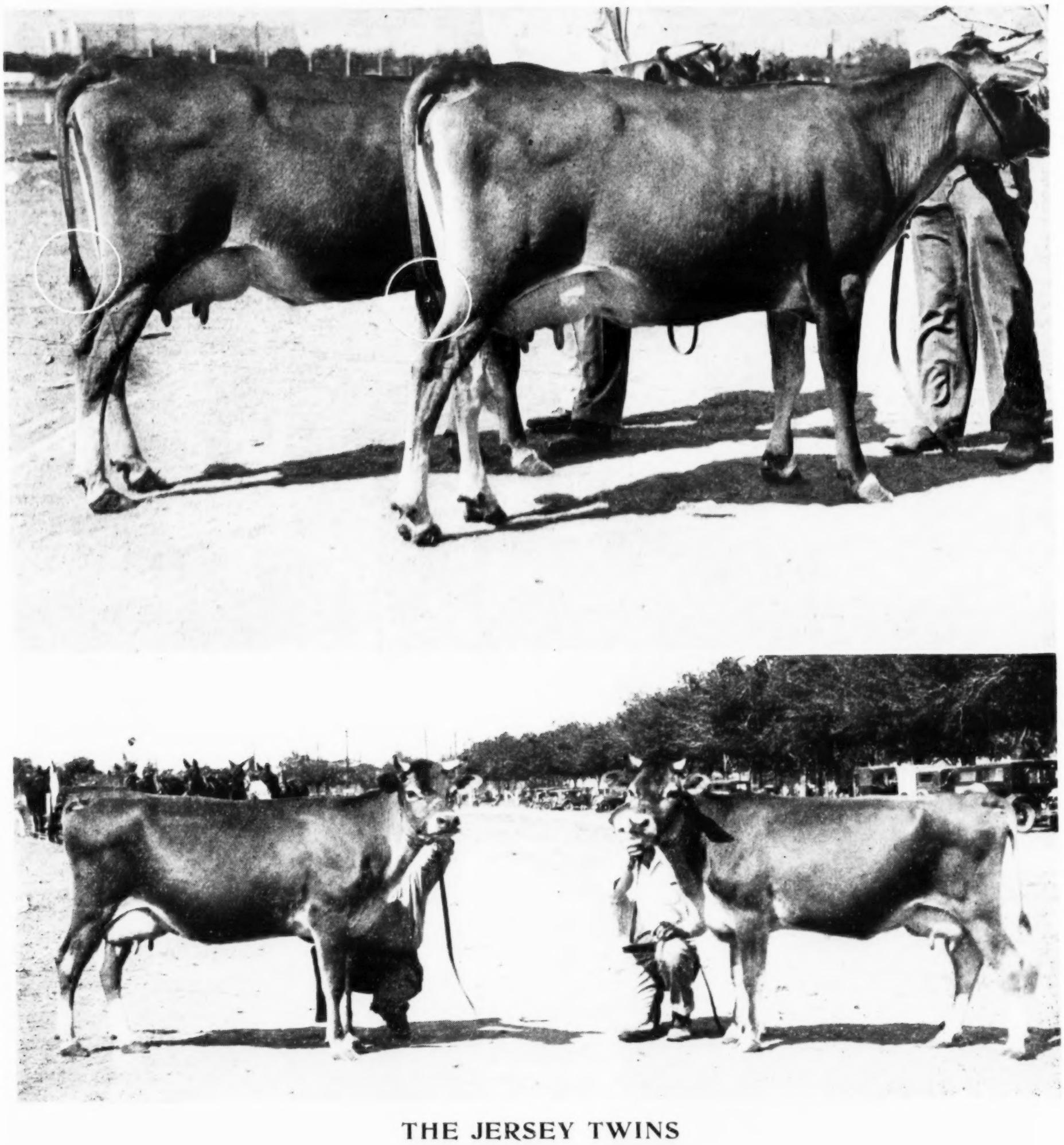
THE contents of this volume are gleaned from the works of the author and his colleagues and arranged to show a progressive picture of the relationship between data of cytologists and geneticists who are attempting to solve the problems related to the behavior of heritable characters.

The book may be classed as a text and reference book. There is very little new material offered, but the discussions and the accompanying well-selected illustrations will be helpful to any reader interested in this technical subject.

One feature that seems of special merit is the space devoted to the effect on tissues of killing, fixing and staining reagents. A series of photographs are given to show the transition from living tissue to tissue made up in a permanent mount. It is with some satisfaction that one sees that only insignificant histological changes brought about by well-balanced killing and fixing fluids.

The major thesis is the agreement between cytological and genetical behavior. There is, perhaps, a tendency to slight the studies of those whose work indicates that the agreement is not perfect. The material is so chosen that one finds little which does not support a hand-in-glove relationship between chromosomes and Mendelian heredity with its recent additions.

A. E. L.



THE JERSEY TWINS

Figure 7

The only bodily difference observed between these twin Jersey heifers is that one of them has a slightly wider band of black hair on her tail than the other (indicated by circles in top picture). In milk yield the heifers also showed well-nigh incredible similarity. They are owned by O. L. Stansell, Floydada, Texas, and photographed October 11, 1928, at the State Fair at Dallas.

TWINS IN JERSEY CATTLE

Apparently Identical

JAY L. LUSH

Animal Husbandman, Texas Agricultural Experiment Station

AN incident attracting unusual attention at the Texas State Fair at Dallas, in October, 1928, was the showing of twin Jersey heifers in the class for heifers two years old and under three. The heifers were so remarkably like each other that even the casual spectators noticed it. After placing the class, the judge stated that the twin heifers were so nearly alike that it really made little difference which one was placed above the other. He was sure, however, that no other cow could be so like them as to deserve to be placed between them in the show ring. They had been shown together before at two large regional fairs. They had stood side by side in both cases. The placing of the two at the first fair had been reversed at the second fair. They were good enough to stand seventh and eighth in a strong class of seventeen at the Texas State Fair.

Their names and registry numbers are Allen's Premier's Darling, 729732, and Allen's Premier's Dainty, 729731. The owner is Mr. O. L. Stansell, Floydada, Texas, and it was through his courtesy in posing the heifers that the accompanying pictures were obtained.

Their remarkable similarity includes color as well as body conformation and size. The patterns of the white spotting are remarkably alike as may be seen by observing the briskets, underlines, and feet in the accompanying pictures. The only definite color difference noted by the writer was that the ring of short black hairs around the upper end of the switch was about one-half inch wide on one heifer and a little more than an inch wide on the other. There was also a very slight difference in the curvature of the horns. Udders and teats were remarkably alike in size and shape. A slight difference in the set of the right rear teat is evident in one picture.

More remarkable still, the two heifers dropped their first calves on the same day, March 12, 1928, within about three or four hours of each other, one calving about five o'clock in the morning and the other between eight and nine the same morning. Both were placed on Register of Merit tests and are giving a creditable performance. Each seems likely to produce about a hundred pounds of fat more than the minimum entrance requirement of the Register of Merit. The milk and fat yields by months, so far as shown by the reports yet received by the State Superintendent of Official Testing are given below.

These fat records are tentative, of course, and will be rechecked and recalculated when the test is completed, making due allowance for variations in the fat tests. The tentative records presented below show a closeness of

	Milk Yield, lbs.			*Fat Yield, lbs.*		
	Darling	*Dainty*	*Difference*	*Darling*	*Dainty*	*Difference*
March	353	354	— 1	20.90	16.71	4.19
April	677	656	21	40.08	30.96	9.12
May	735	754	—19	39.18	38.45	.73
June	645	629	16	29.15	30.00	— .85
July	674	672	2	39.77	31.32	8.45
August	724	716	8	37.79	37.80	— .01
September	613	600	13	33.16	32.40	.76
October	590	558	32	34.22	33.48	.74
November	552	540	12	35.05	36.72	—1.67

agreement with respect to milk yield which would be well nigh incredible under any other hypothesis than that the cows really are identical twins and that the response of the milk yield to tangible environmental influences is almost totally determined by the hereditary constitution of the cow. The fat yields show six cases of equally close agreement and three cases of rather large differences. Pending the final calculation and certification of the records we cannot judge the significance of the deviations in March, April, and July fat records. Since all three of these deviations are in the same direction, one hesitates to ascribe them to chance fluctuations caused by variations in the technique of testing. It should be noted, however, that all three rest primarily upon a difference in test rather than upon a difference in milk yield. It should also be noted that the fat yield for April and for the fractional part of March included are both calculated from the same test. Therefore the March and April differences are really only a single difference in fat test, and we have here to deal with a series of records which parallel each other marvelously except for the fat tests on two occasions. When Student's method is applied to the fat tests, the differences in average tests for the two cows are found to be statistically not significant, the probability being about .38 that a difference as large as this in either direction might arise by chance alone. The difference in the March-April test and in the July test are distinct from the other six differences, however, each deviating from the average of the other six by more than five times the standard deviation of the six.

This is not a case of heredity *vs.* environment in the sense in which the case of human twins reared apart and reported by Muller[5] was. Here both heredity and environment are alike, heredity absolutely so if these heifers really are identical twins, and environment as nearly alike as it could be made under practical dairy farm conditions. The heifers were stall-mates and were carried together on the show circuit. This case would be most illuminating if compared with cases of full sisters reared and tested in the same herd under standard conditions. The genetic correlation between such full sisters would be about .50 unless considerable inbreeding existed in their pedigrees, while in the case of these presumably identical twins it would be 1.00. It is doubtful whether many records of full sisters could be obtained. They would necessarily have to calve at the same time if the environment were to be the same with respect to weather condition, quality and amount of pasture, minor variations in the quality of dry feeding stuffs, etc. Even if such conditions were fulfilled an age correction would be necessary because the rarity of plural births in cattle [1, 2, 3, 4] would make exceedingly improbable the finding of di-zygotic Jersey twin cows which had been officially tested at the same dates.

This case will therefore probably remain only an interesting instance of cattle twins which are almost certainly identical in view of their very close physical resemblance and which suggest by the remarkable agreement of their production records that most variations in milk or fat production not directly traceable to differences in age, feed, weather, methods of management or other tangible environmental factors are direct results of genetic differences.

Genetic studies in recent years have shown that the age-old question of heredity *vs.* environment is not really a case of heredity *or* environment at all but is a case of environment operating continuously on a mechanism initially determined by heredity. The product of the two is in some respects very much the same regardless of wide variations in the environmental forces. In other respects the product is very definitely changed by even

small variations in the environmental forces. It is only for convenience of speech that we say that the former product (e. g., hair color) is determined by heredity and the latter product (e. g., fatness) is determined by environment. Both products are the end-result of environmental forces operating on a mechanism provided by heredity. They differ only in the degree to which variations in environmental forces or in genetic constitution produce measurable differences in the end products. Wright[6] has shown that some variations in coat color in guinea pigs are not explainable either as the result of genetic differences or as the result of definite environmental factors. The surprisingly close agreement in the production records of these twin cows, although but a single case, suggests that such vagaries of development play an exceedingly small rôle in determining the production of milk and of fat by Jersey cows.

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Evolution and Fanaticism

THE key is lost by which I might unlock the perverse malady from which my father's conscience seemed to suffer during the whole of this melancholy winter. But I think that a dislocation of his intellectual system had a great deal to do with it. Up to this point in his career, he had, as we have seen, nourished the delusion that science and revelation could be mutually justified, that some sort of compromise was possible. With great and ever greater distinctness, his investigations had shown him that in all departments of organic nature there are visible the evidences of slow modification of forms, of the type developed by the pressure and practice of aeons. This conviction had been borne in upon him until it was positively irresistible. Where was his place, then, as a sincere and accurate observer? Manifestly, it was with the pioneers of the new truth, it was with Darwin, Wallace and Hooker. But did not the second chapter of "Genesis" say that in six days the heavens and earth were finished, and the host of them, and that on the seventh day God ended his work which he had made?

Here was a dilemma! Geology certainly seemed to be true, but the Bible, which was God's word, was true. If the Bible said that all things in Heaven and Earth were created in six days, created in six days they were—in six literal days of twenty-four hours each. The evidences of spontaneous variation of form, acting over an immense space of time, upon ever-modifying organic structures, seemed overwhelming, but they must either be brought into line with the six-day labor of creation, or they must be rejected. I have already shown how my father worked out the ingenious "Omphalos" theory in order to justify himself as a strictly scientific observer who was also a humble slave of revelation. But the old convention and the new rebellion would alike have none of his compromise.

To a mind so acute and at the same time so narrow as that of my

father—a mind which is all logical and positive without breadth, without suppleness and without imagination—to be subjected to a check of this kind is agony. It has not the relief of a smaller nature, which escapes from the dilemma by some foggy formula; nor the resolution of a larger nature to take to it wings and surmount the obstacle. My father, although half suffocated by the emotion of being lifted, as it were, on the great biological wave, never dreamed of letting go his clutch of the ancient tradition, but hung there, strained and buffeted. It is extraordinary that he—an "honest hodman of science", as Huxley once called him—should not have been content to allow others, whose horizons were wider than his could be, to pursue those purely intellectual surveys for which he had no species of aptitude. But he was more an attorney than a philosopher, and he lacked that sublime humility which is the crown of genius. For, this obstinate persuasion that he alone knew the mind of God, that he alone could interpret the designs of the Creator, what did it result from if not from a congenital lack of that highest modesty which replies "I do not know" even to the questions which Faith, with menacing finger, insists on having most positively answered? . . .

My holidays, however, and all my personal relations with my father were poisoned by this insistency. I was never at my ease in his company; I never knew when I might not be subjected to a series of searching questions which I should not be allowed to evade. Meanwhile, on every other stage of experience I was gaining the reliance upon self and the respect for the opinion of others which come naturally to a young man of sober habits who earns his own living and lives his own life. For this kind of independence my Father had no respect or consideration, when questions of religion were introduced, although to me the reflection, which in years to come I was to repeat over and over, with an ever sadder emphasis—what a charming companion, what a delightful parent, what a courteous and engaging friend, my father would have been, and would pre-eminently have been to me, if it had not been for this stringent piety which ruined it all.

Let me speak plainly. After my long experience, after my patience and forbearance, I have surely the right to protest against the untruth (would that I could apply to it any other word!) that evangelical religion, or any religion in a violent form, is a wholesome or valuable or desirable adjunct to human life. It divides heart from heart. It sets up a vain, chimerical ideal in the barren pursuit of which all the tender, indulgent affections, all the genial play of life, all the exquisite pleasures and soft resignations of the body, all that enlarges and calms the soul, are exchanged for what is harsh and void and negative. It encourages a stern and ignorant spirit of condemnation; it throws altogether out of gear the healthy movement of the conscience; it invents virtues which are sterile and cruel; it invents sins which are no sins at all, but which darken the heaven of innocent joy with futile clouds of remorse. There is something horrible, if we will bring ourselves to face it, in the fanaticism that can do nothing with this pathetic and fugitive existence of ours but treat it as if it were the uncomfortable ante-chamber to a palace which no one has explored and of the plan of which we know absolutely nothing. My father, it is true, believed that he was intimately acquainted with the form and furniture of this habitation, and he wished me to think of nothing else but of the advantages of an eternal residence in it.—Gosse, Edmund. Father and Son: A Study of Two Temperaments. Pp. 128 and 347.

THE WEEDISHNESS OF WILD OATS

A Reluctant and Backbreaking Study in Adaptation

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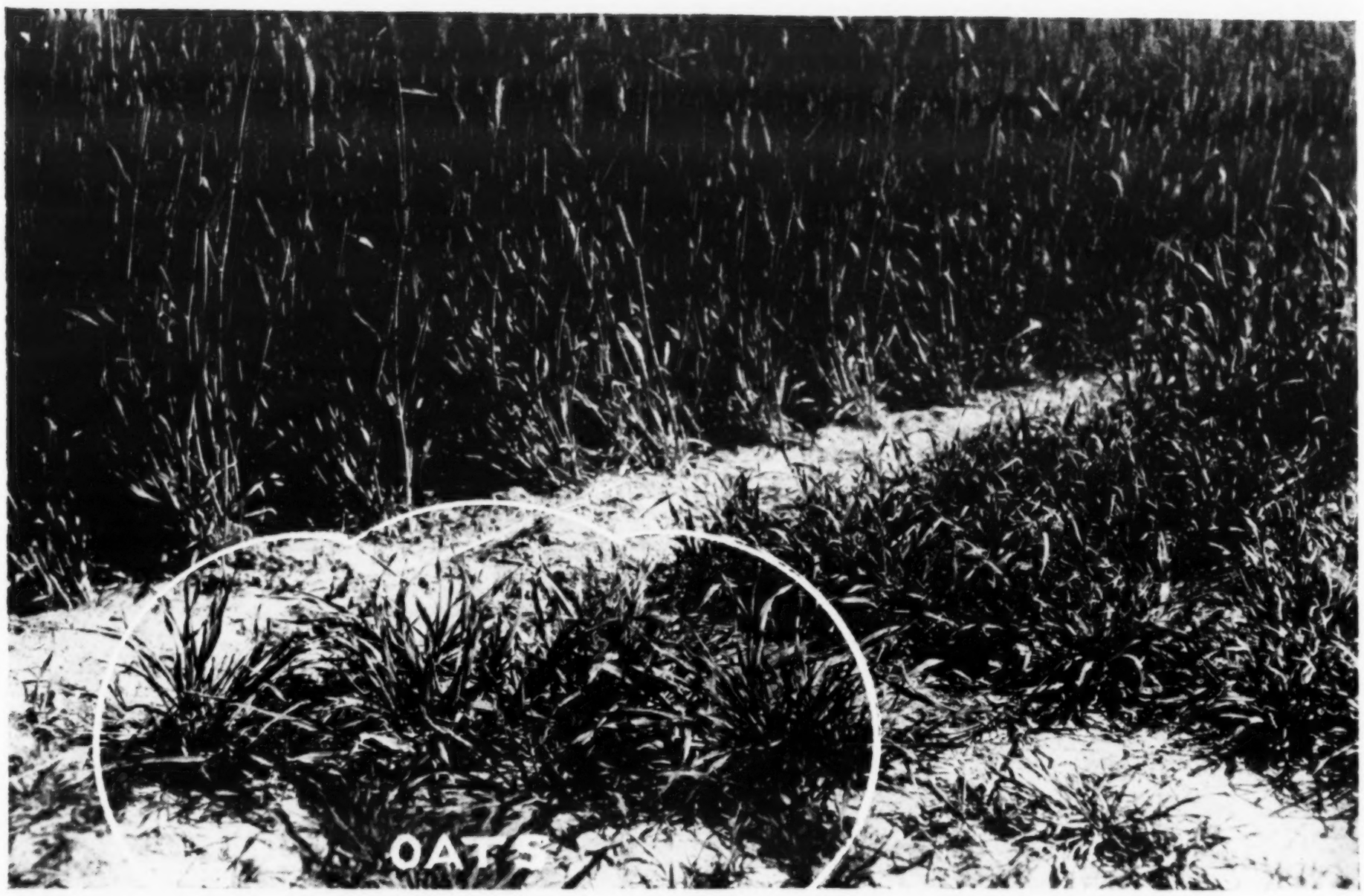
A PERFECT WEED

Figure 8

A plant of wild oats in wheat row at Sacaton, Arizona, in 1927. Note that the cat plant is about the same height as the wheat adjoining it. On the same day wild oats in winter barley nearby were only six or eight inches tall, and showed no signs of heading, as shown in Figure 9. The ability of wild oats to "keep step" in growth with the plants surrounding is an attribute that adds greatly to efficiency as a weed, attested to by these photographs and the author's memories of a disappointing summer.

THEY say you must suffer to understand. I've suffered. However, it really starts some years back. One summer I went into the field and ran a chemical balance from 5 A. M. to 7 P. M. for twenty-six consecutive days. Before it was over I quarreled with everything within twenty miles that could talk. When I returned to the Office I met the usual line: "You must have had a wonderful vacation. Of course you had work—we don't mean that—but it's such a change, it's much the same thing." Year after year the same stereotyped greeting met me and gradually it implanted an impure and treacherous idea in my brain. Why not do that little thing some time? So, last year was the chosen year of idleness. At one point I planned carefully—adding naturally a few things that would be "interesting." However, when all was settled I had nothing to do but take



WILD OATS KEEP "IN STEP" WITH THEIR NEIGHBORS

Figure 9

Two views taken on the same day showing wild oats growing at Sacaton, Arizona. The upper view shows oats and winter barley in the foreground, the barley is to the right of the oats which are outlined in white. The oats plants are sprawled all over the ground, just as is the winter barley. Below is shown the tallest oat plant, found in a row of durum wheat which was heading. The oats in the tall grain were all tall; no plants were observed in the winter rosette stage, like that in the late barley in the upper photograph.

THE LONG AND SHORT OF IT

Figure 10

Two oats plants typical of those found in the rows in which they are growing. Where the companion grain crop was tall the oats were tall; if the barley was short the oats never became tall. In one very late and tall form of durum wheat the oats were six feet tall, and just as late as the wheat.

notes on 2400 rows, make a hundred or so crosses and harvest, thresh and weight 1800 rows. The harvesting operations had to be carried out with no equipment other than a jacknife, a cloth bag and a club. Still, there were four whole months **to do it in.** A week went by leisurely, placidly and restfully. Then I saw some plants that were not barley. A few barley rows with some wild oats to be removed! Nothing serious! I started in. As the eye became more expert the oats became more numerous. I pulled all day when not busy with notes and crosses. The next day was the same—and the next. The days had to be lengthened and the notes rushed. Still more oats So it went until the day of harvest. On the third time over, from one 10-foot row I removed 78 plants of wild oats.

One can think while pulling oats, though possibly most of the thoughts had better remain a personal matter. However, as I watched the unrushed year assume the usual hectic tension, I could not but gather a little of the philosophy of wild oats. What was there about this plant that made it such a perfect weed? Why did I have to go over the rows so often? I had pulled them out by the thousands before they came in head. Why did I not catch the remaining ones on the first pulling after heading? The answer was apparent but, so far as I know, not much commented upon in cereal literature. The wild oat is adaptable to a degree not thought of in high pressure salesmanship. In the nursery there were both wheats and barleys and each of these grains was represented by both spring and winter forms. This meant that the various stages of growth were all over the map. Barleys were heading when adjacent barleys were in the winter rosette. Barleys were ripe when wheats five feet away were still in the earliest stages of shooting. Each individual sort behaved as its inherent impulse decided, unaffected by neighboring sorts except for small variations in height. Not so wild oats! Length of day may rule barley and wheats but with the oats "keeping up with the Joneses" is the governing factor. This applies not only to time factors but to height. On the same

day all stages of wild oats could be found. In the winter grains they sprawled over the ground with the most approved of winter habits, apparently weeks from heading. In the stooling grain they were erect and growing rapidly. In the heading grain they were flowering. All were from the same date of planting. This same relationship to maturity was maintained for weeks. Only among the very latest sorts did the oats come out ahead of the companion grain crop.

The height relationships were equally striking. At none of the early stages could oats be removed by difference in height, although the grain rows varied enormously. Even at heading-time the oats headed at the same height as the row in which they were found. If the barley was short, the oats never became tall, but if the barley was tall the oats were tall. There was in the nursery one form of durum wheat which was very tall and late. Wild oats in this variety were late and nearly six feet tall.

Vavilov's conception of oats as a weed plant probably has more facts back of it than have been brought out, and we suspect primitive farmers back in the place and days where oats became oats did less fishing in the summers than they had hoped.

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the Journal will be reviewed in later numbers.

WHY WE ARE MEN AND WOMEN, FACTORS DETERMINING SEX. *By* A. L. BENEDICT, M. D., A. M., F. A. C. P. Pp. 270. Price $2.50. Illustrated with charts. Allen Ross & Co., New York. 1929.

An attempt to harmonize fads, facts and fancies with scientific observations with regard to sex—let us hope successfully!

STERILIZATION FOR HUMAN BETTERMENT. *By* E. S. GOSNEY and PAUL POPENOE. A Summary of Results of 6,000 Operations in California, 1909-1929 Pp. 202. Price $2.00. Macmillan Co., New York, 1929.

More facts about a controversial subject than can be found between any other two covers.

URSPRUNG UND VERERBREITUNG DES MENSCHENGESSCHLECHTS. *By* FRANZ KOCH. 42 Illustrations, 14 Charts, 15 Plates. Pp. 174. Price, paper binding—11 Mk., cloth binding—13 mk. Jena, Verlag von Gustav Fischer. 1929.

YEARBOOK OF THE BERGEN MUSEUM, NORWAY. *Edited by* CARL FRED. KOLDERUP, Director. 14 Plates, 5 Text-figures. English summary. Pp. 202. Bergen, John Griegs Boktrykkeri. 1929.

Containing an extended article on the color changes of the Willow Grouse in Norway. Illustrated with an excellent series of colored plates.

THE INHERITANCE OF NATURAL IMMUNITY AMONG ANIMALS

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SCIENTIFIC men have long been concerned with the possibility of breeding disease resistant strains. Burchardt (1880) was one of the first to observe the inheritance of resistance to disease among animals. Probably the first experiments conducted along this line were those of Chaveau in 1880 to ascertain the inheritance of immunity to anthrax in sheep. Similar experiments were conducted by Arloing and Kitasato in 1892 and by Cornevin and Thomas in 1894. However, the first exact researches on the inheritance of immunity date from those of Ehrlich in 1892. Since that time various experiments have been conducted in this field by both American and foreign investigators.

That the development of disease resistant breeds and strains will be one of the more important phases of genetic work in the future is highly probable. Even superficial observation shows that not all animals are equally susceptible to a given disease since, during the course of epidemics there are usually some individuals which, although freely exposed, escape infection. A given micro-organism may be capable of causing a fatal infection in some individuals of a population, while in others it may have little or no effect. From such naturally immune individuals disease resistant strains and breeds will be derived.

It must be borne in mind that immunity and susceptibility are relative terms. Every infectious disease is due to the struggle between the individual attacked and the pathogenic action of the microorganism, the vigor of the attack and the counter attack will vary under various physical and physiological conditions. It is for this reason that the resistance to a particular disease will vary during the life of the individual.

From the point of view of the animal body there is little doubt but that the development of resistance is a matter of inheritance. The individuals that are best endowed to resist a particular disease are the ones that remain to reproduce the succeeding generation, thus leaving the race more resistant to the organism. Also, since races of a given species will come in contact with different micro-organisms in different geographical localities, variation in immunity to different diseases will be developed among the same species. Those that have been exposed the greatest number of generations will have the greatest resistance. This is well borne out by the prevalence and severity of some of the diseases in man. Syphilis when first reported authentically in the fifteenth century among the Caucasians is described as sweeping epidemically through Europe as an acute and violent disease. Today the Caucasian race is relatively immune to syphilis, yet among some of the aboriginal races that have been exposed to the disease in more recent times it is a veritable plague.

Factors of Immunity

The mere fact that animals are constantly in contact with micro-organisms of virulence, indicates in itself that many individuals have a high degree of efficiency in warding off diseases. To a certain extent the skin and mucous membranes prevent the organism from entering the body. The gastric juice, saliva and intestinal secretions prevent certain organisms from entering the body by way of the alimentary canal. But even if the organism enters the body, there is still another means or defense. The leucocytes are ever on

guard to dispose of any organisms and foreign material. It has been demonstrated that the immunity of the frog to anthrax is at least in part due to the phagocytic activity of the leucocytes.

In a large number of animals the blood serum exerts a bactericidal effect upon the micro-organisms. A natural antitoxin may also be present. Thus the natural immunity of the alligator to tetanus toxin is due to the natural antitoxin in the blood. The immunity of many human beings and horses to diphtheria is also due to natural antitoxin. It should, however, be borne in mind that antibodies may in some cases be due to previous minor infections. Some animals have natural antibacterial substances in the blood serum. This is due to the presence of two substances, the thermostable substance (amboceptor) which combines with the bacteria and a thermolabile substance (complement) which in turn combines with the amboceptor after it has combined with the bacterial cell. Both are normally found in the blood serum of certain animals. The immunity of the rat to anthrax is due to the presence of these two substances in the blood serum. The presence of antiaggressines, which are the substances that prevent the micro-organisms from exercising their special aggressive forces, will aid in immunizing an animal to certain organisms. This applies especially to such organisms as anthrax bacillus, which is markedly aggressive but only slightly toxic.

Lack of suitable receptors on the part of the body cells is another factor in some animals. Temperature may also be a factor as in the immunity of the lizard to plague. At 16° C. no infection takes place, but if the temperature is increased to 26° C. the resistance is broken down, making infection possible. Even among warm-blooded animals a difference in temperature appears to be the basis of immunity of certain species of animals. The immunity of birds to bovine tuberculosis and of cattle to avian tuberculosis is due to the differences in body temperatures. In other cases immunity is due to lack of nutrients. Gonococcus infection can take place only in the human being because of the particular protein found in the tissues. To a certain extent in all animals some or all of these factors operate, but they will vary with different species, races, or even individuals.

Species Immunity

A specific disease may occur only in a single host species or it may be capable of spreading throughout a variety of different animals. Hog cholera affects only hogs, while anthrax bacillus produces a characteristic disease in man, as well as in many of the lower animals. Numerous diseases affecting man, such as typhoid fever, diphtheria, scarlet fever, measles, influenza, yellow fever and Asiatic cholera are limited to this host alone. Other warm blooded animals are naturally insusceptible, due to the unsuitable cultural conditions in the body of the host. It is this principle that prevents the transmission of diseases from cold-blooded to warm-blooded animals and vice versa.

Under normal conditions it is impossible to infect cold-blooded animals with diseases common to warm-blooded animals, yet by increasing the temperature the same may be accomplished. This type of immunity might be considered absolute and is rarely found in the animal kingdom except in diseases caused by protozoa. The protozoa are generally restricted to one species, though other species may not differ strikingly in temperature or metabolism.

As yet little is known concerning the phenomena of immunity in the lower animals belonging to the great group of invertebrates. But there is very little doubt that they are endowed with natural immunity similar to that found in higher animals. For example, Metchnikoff found that the larvae of the rhinoceros beetle (*Oryctes nasicornis*) were very susceptible to cholera virus but exhibited a remarkable natural immunity against the bacilli of anthrax and diphtheria. Crickets contract an-

thrax very readily even at moderate temperatures, but they are, according to Kovalevsky, refractory to the bacillus of avian tuberculosis. Cases of immunity in insects have also been observed by Paillot who attributed the immunity exclusively to the action of antibodies in the blood. He also observed a case of acquired immunity in the caterpillar of Agrotis to *Bacillus melolotonthae non-liquefaciens* where he found a more rapid production of antibodies than in vertebrates.

Among mosquitoes we also have a striking example of species immunity. One species of Anopheles (*A. maculipennis*) is quite susceptible to and a well recognized carrier of the malaria parasite, whereas *Anopheles punctipennis*, though closely related, is not susceptible to it.

The immunity of protozoan animals against infectious diseases and toxic agents is as yet very imperfectly understood. It has been observed that protozoa are often attacked by minute, mobile, colorless parasites which destroy enormous numbers of the infurosia. Yet Paramecia withstood perfectly well doses of cultures of diphtheria and tetanus bacillus.

As might be expected from the evolutionary point of view, cases of species immunity are common and often absolute. Different species, evolving under different conditions, many living in different geographical localities, would naturally encounter different microorganisms to which they would develop immunity by the selective process. From the point of view of genetics, species immunity can never play a very important part in the development of disease resistant animals due to the physical differences and sterility encountered upon hybridization.

Racial Immunity

Well marked examples of racial immunity, which is the immunity existing among members of the same species, are fewer in number than those between species. For example, Negroes are believed to enjoy immunity to yellow fever and Japanese to scarlet fever. Small pox is considered a relatively mild disease in Mexico, yet among North American Indians it is a dreaded epidemic. The extraordinary susceptibility of the negro to tuberculosis is familiar to all American physicians, and it is a well known fact that the Eskimo, transported to temperate climates, contracts infectious diseases. The Arabian, likewise, contracts tuberculosis when transported to a city. In New York it has been found that the Russians, Poles and Jews are much more resistant to tuberculosis than are certain other nationalities, particularly the Irish. The Chinese appear relatively immune to *B. tetanus*. Measles is considered a mild disease among Caucasian people, but among the North American Indians and Melanesians it is very severe, spreading through tribes like a veritable plague and proving fatal in many cases. The Malaysians are very susceptible to beri-beri, while other races are relatively immune.

Among domesticated animals the Algerian sheep is a striking example of racial immunity. It is the only breed of sheep that is not susceptible to anthrax. In the Zebu we seem to have an analagous condition, for, according to Pucci, a male and female Gujarot Zebu among seventy brown Alpine cows were the only individuals unaffected by the foot-and-mouth-disease. They also appear to be immune to Texas fever and anthrax. According to Johnson and Bancroft the native cattle of Asia and certain provinces of Queensland are tick resistant. Of the common breeds of cattle, the Jersey appears to be least affected by cattle tick.

The Japanese waltzing mice are very susceptible to implantations of tumor while the common mouse is entirely immune. Haaland inoculated various strains of mice with tumor and found that nearly one hundred per cent of the Berlin mice were susceptible while only twenty-four per cent of the Hamburg mice and practically none of the

Christiana mice grow the tumor. He found in addition that the degree of susceptibility of any one strain varied according to the geographical location. Wide variations with respect to the degree of susceptibility to implantations of tumor in mice, with the locality as a modifying factor, was also observed by Cuenot and Mercier in their extensive work on the subject. Lathrop and Loeb, after eliminating possible influencing factors such as climate and food, still found great variation in the incidence of cancer of the mammary glands among female mice. The strain designated "English" reacted 66.9 per cent, "Carter" 35 per cent "No. 8" 30 per cent, "Cream" 3.33 per cent, "English tan" 73 per cent, "English sable" 76 per cent and "English 101" 65 per cent. The tumor rate in any one strain remained fairly constant. However, in a few cases an apparent increase of cancer incidence was observed after the first two generations. It was also possible to obtain different substrains by selection. Stahr, Bullock and Curtis, Slye, Murray, Tyzzer and others also observed variations among various races, strains and families of mice in their degree of susceptibility to cancer implantation.

The grey mice are, as a rule, more resistant to streptococcus and pneumococus infection than are white mice. White mice are more susceptible than other strains to infection with *Bacillus abortus*. The field mouse is immune to glanders, while the house mouse is susceptible. Muller's experiments on black and white rats treated with anthrax bacillus resulted in the survival of 79 per cent of the former and only 14 per cent of the latter. Gay found that rats obtained from various sources varied markedly in their degree of susceptibility to transplantation of tumor. One strain gave a 100 per cent of "takes" while in the next most susceptible strain only 50 per cent gave positive results. Marked variation of this kind were also observed by Loeb. Sarcoma which was readily propagated in white rats, failed to grow when inoculated into pigmented rats. The probability that all species of animals have disease resistant races and the fact that hybridization is easily accomplished within a species makes immunity developed by hybridization the most promising procedure for the generation of disease resistant breeds of animals.

Individual Immunity

Individual immunity, while not infrequent, is not constant and is seldom absolute. During times of epidemics there are always individuals who escape though brought in intimate contact with severe infections. It is a well known fact that children of the same family, living under the same conditions and approximately of the same age will vary in their degree of resistance to exanthematous diseases such as scarlet fever and measles. As already stated some fifty per cent of human beings and thirty per cent of horses are naturally immune to diphtheria. Individual immunity to various other infectious diseases is not uncommon.

H. L. Amoss, in his experiments on the effect of the addition of healthy mice to a population suffering from mouse typhoid, found that there were always a few individuals that did not contract the disease. Webster, likewise, found that normal mice varied in resistance to injections of *B. enteritidis* (murium). He also found that mice varied considerably in their tolerance to injections of bichloride of mercury. Even in as small a group as twenty individuals, where age, weight and environmental conditions were constant marked variation was observed. The degree of immunity varied from almost completely resistant individuals to highly susceptible ones. Similar results were obtained by Smith in his work with guinea-pigs. He found that individuals of the same family were usually equally susceptible or resistant and that several litters of the same mother gave the same ratio. Lewis, who worked with inbred guinea-pigs, rats, mice and rabbits, likewise found a

wide range of individual variation in susceptibility to tuberculosis. Jorgenson, in his field and laboratory studies observed great variation in the degree of susceptibility of pigs and rabbits to enteritis. Professor Rich, in his bulletin on infectious abortion states that there are millions of cattle all over the world that have a natural immunity to *B. abortus*. Among tubercular herds of cattle, there are always some individuals that though exposed do not contract the disease. According to the Indian Plague Commission fifty-nine per cent of the rats inoculated by the cutaneous method with the spleen of infected rats are immune to the plague. Experiments conducted in the federal laboratory in San Francisco showed that a large number of rats inoculated with highly virulent cultures of *B. pestis* were immune. Immunity was more frequent among the large rats. When tissues infected with *B. pestis* were substituted for the culture itself and injected subcutaneously about fifteen per cent of the small rats and about fifty per cent of the large ones were found immune.

Apart from the explanations outlined under the mechanism of natural immunity, the factors determining immunity are largely a mystery. Species resistance may to a large extent be due to such factors as temperature. In racial variation, of course, there are no instances in which such very obvious physiological factors play a part. However, such factors as adaptation of micro-organisms to special nutritional conditions may enter in. Gonococcus, for instance, infects man only, because it requires human protein for growth. The fact that certain diseases are infectious to more than one species of animals merely implies an increased ability on the part of the bacteria to meet altered cultural conditions and also a greater invasive power with which to meet the particular defenses opposed to it by a given animal. In the case of cancer, age, sex, pregnancy and other physiological conditions are additional factors. That they may apply to a large number of other diseases is highly probable.

Whether immunity among different species is to be interpreted as an instance of the survival of the fittest or whether immunity acquired by an individual can be wholly or in part transmitted to the offspring is not entirely a closed question. For instance, Redfield, in an article on race immunization, points out that small pox is becoming less common among the white race due to the inheritance of resistance developed by vaccination. He also presents data concerning 381 tubercular patients at the Crossly Sanitorium at Fordsham, England, showing that the greater the extent to which parents have exercised their power of fighting tuberculosis before their children were conceived, the greater is the resistance of the children to that disease. Redfield also believes the resistance to syphilis can be built up in the same way. However, resistance to plague and infectious diseases among man and animals lends itself to another interpretation. The plague eliminates the most susceptible and leaves the race in this way more resistant. The inborn power of resistance which may be enhanced by the selective process, especially if the plague is very severe and lasts a long time, is the thing transmitted. On the other hand there is very little if any evidence of the transmission of acquired immunity.

Transmission of Passive Immunity.

Though there is not a single conclusive demonstration of the inheritance acquired immunity, there is sufficient evidence that resistance to diseases can be transmitted by immunized mothers to the offspring. This, however, merely consists of the transmission of specific antibodies by way of the placenta and colostrum. Burchardt as early as 1879 observed that young born to sheep that had been inoculated with the virus of sheep pox, were resistant from four to six weeks, after which time the immunity was lost. Chaveau (1880), likewise, demonstrated that young born to

sheep previously immunized to anthrax possessed a high degree of resistance to this disease. Famulener (1912), in his experiments on the transmission of immunity from mother to offspring found that goats actively immunized against sheep blood corpuscles during gestation passively transmitted the specific hemolysins to their young. Colostrum was the chief agent in bringing about passive immunization of the suckling. The placenta played a minor rôle in the passage of hemolysins to the young before birth; practically negligible is most cases. Mother goats immunized after birth of their young failed to transmit any demonstrable immunity through the milk.

Milton, Rosenau and Anderson in their studies on hypersusceptibility of guinea-pigs to toxic action of horse serum found that it was transmitted through the female but not through the male. The susceptibility was not transmitted through the milk. Reymann (1920), as a result of his work concluded that antibodies were probably transmitted by the way of the milk. The above results, concerning the negative influence of the father in the transmission of immunity, agree with those of Remlinger, Ehrlich, Hubener, Vaillard, Wernicke and Hadley. Hadley found that some of the rabbits immunized against fowl cholera were able to produce immune offspring twenty-seven months after the date of immunization.

Smith, who worked with guinea-pigs immunized against diphtheria toxin, likewise, found that the ability of the immune mother to transmit resistance is of fairly long duration. Reynolds, Tappaz, Anderson, Howell, Ely, Sudmersen, Glening, Krause, Birch and Gerlach among others found similar results concerning the transmission of passive immunity from mother to offspring. However, they differed somewhat as to the method of transmission. Their conflicting results may be due, as Guyer pointed out in one of his papers, to different types of antibodies concerned and to the fact that structurally the placental relations between mother and the young are different in different kinds of animals. Guyer and Smith in their experiments on the production of typhoid agglutinins in successive generations of rabbits found that the antibodies not only pass through the milk but also through the placenta. The young of immunized mothers can transmit the agglutinating ability to their offspring without further immunization. However, higher agglutination titers were obtained from individuals derived from strains that were immunized for three or four successive generations than in the first generation animals of untreated stock.

It is evident from the above experiments on the transmission of passive immunity, that the resistance of the offspring to a particular disease depends upon the transmission of antibodies either by way of the placenta or colostrum, and is generally of short duration, usually about five weeks. It is not conveyed through the male, and is not usually present in the second generation of the young.

Inheritance of Natural Immunity

Though considerable experimental work has been done on the transmission of passive immunity, but few thorough studies with the exception of that on cancer have as yet been made concerning the inheritance of natural immunity. While considerable interest has been shown in this field of work even before the rediscovery of Mendel's law, practically all of the exact experimental work has been done during recent years.

Loeb and Lathrop, as a result of their extensive work on the inheritance of predisposition of cancer in mice, found that crosses between strains with a marked difference in incidence of cancer resulted in offspring which were in the main intermediate between the parent strains. However, all degrees of intermediancy were obtained. The cancer rate of any one strain persisted through successive generations with surprising regularity. Hybrids from strains

with about the same tumor rate, had a tumor incidence common to both parents. They also observed that the age at which cancer occurs was as characteristic in any one strain as the incidence of cancer. While no definite sex-linkage was observed, there was an indication that in certain cases a sex-linked factor entered in as one of the multiple factors. They attributed the inheritance of predisposition to cancer in mice to the cooperation of multiple factors. "Variation in the number of characters of multiple factors in the different individuals may be responsible for the variation in intensity which determines the tendency to cancer in individuals and different strains may differ as to the mean in the distribution of the factors among individuals belonging to the strain."

Tyzzer in his studies of spontaneous tumors in mice found that the frequency of tumor was more evident in some strains than in others, which he attributed to inherited characters or qualities. The implants of this tumor have been observed to grow in 98 per cent of the Japanese waltzing mice inoculated, while common mice have proved in every case nonsusceptible. Furthermore, as a result of cross-breeding of susceptible Japanese waltzing mice with common mice, it has been found that the hybrids of the second filial generation are in all cases nonsusceptible to the tumor. As a result of later experimental studies by Little and Tyzzer on the inheritance of susceptiibility to transplantable tumor with the same strains of mice, it was concluded that the tendency to take a tumor graft depended upon multiple factor inheritance,—the number of factors being rather large, probably twelve to fourteen. Little and Johnson in their experiments on the inheritance of susceptibility to implants of splenic tissues in Japanese waltzing mice and albinos, likewise, found that it depended upon the same general principles of heredity found to apply in the case of tumor tissue—namely, multiple Mendelizing factors. This view was also supported by the work of Little and Strong in their work on the susceptibility of mice to transplantation of adenocarcomata. The growth of one of the tumors depended upon the simultaneous presence of two factors and another on at least three factors. In contrast to the multiple factor hypothesis of the above workers, Syle as a result of seventeen years of work and involving nearly 65,000 mice concluded that "the tendency to cancer resistance has proved to be dominant over tendencies to cancer susceptibility and both these tendencies have proved to be unquestionably inheritable, by following with perfection the Mendelian pattern. The type of cancer both primary and secondary and the location where they are liable to occur have also proved to be inheritable both by breeding and by hybridization tests and these characters also have closely followed Mendelian pattern." Lynch, on the other hand, concluded that susceptibility to cancer in mice behaved as a unit character and was dominant over the tendency to resist cancer. However, her results agreed with those of previous workers regarding the variability of the character and that susceptibility to cancer depended to a certain extent upon age. Murray, Cuenot and Mercier, Bullock and Curtis, Marsh and others agree that susceptibility to cancer is inherited but do not define the method of inheritance.

That predisposition to cancer in man is also transmitted in a Mendelian manner, is almost certain. Little noted that the tabulations of family histories on file at the Eugenic Record Office of the Carnegie Institution of Washington indicate inheritance of predisposition to formation of cancer in man. He included all types of indigent tumors under the term cancer. "The influence of inheritance is shown by the occurrence of marked excess of cancerous individuals over rate of general population in (1) sibs of cancerous individuals (2) progeny of cancerous mothers by non-cancerous fathers, (3)

progeny of non-cancerous mothers by cancerous fathers. The fact of inheritance is clear, but the type of inheritance needs further investigation." According to this author it does not appear to be simple Mendelian inheritance. Nor does he at present think that it will be found to depend upon multiple Mendelizing factors. Similar observations have been made in Norway. In certain parts where the population is stationary, marked differences in the predisposition to cancer among certain families have been observed. This is not limited to Norway for a famous case is that of Napoleon Bonaparte who together with his father and two sisters died of cancer.

While no other disease has been studied as intensively as cancer, the results are no less convincing from the hereditary point of view. Thus Webster's experiments tend to show that predisposition of resistance of mice to mouse typhoid depends upon hereditary factors. He was able to produce by selection, strains that were many times more resistant to mouse typhoid than his foundation stock.

Wright and Lewis, as a result of the experimental work with inbred guinea-pigs, concluded that resistance to tuberculosis is transmitted to the offspring in much the same way as are the physical characteristics. Different families varied markedly in their ability to resist infection with tuberculosis. Crossing of two resistant strains resulted in offspring more resistant than either parent, indicating a possibility of complimentary factors. The first filial generation of a cross between two susceptible strains was slightly superior to the more resistant parent indicating dominance of susceptibility. The tendency for resistance to tuberculosis was transmitted by either of the two sexes. Vigor, including rate of growth, adult weight, frequency and size of litter, the percentage of young born alive and the percentage of these raised to weaning, were closely related to resistance to tuberculosis. Lewis in his report at the 2nd International Congress of Eugenics states that the "degree of refraction of inbred guinea-pigs to tuberculosis seems to depend on several resistant factors", which he thought were inherited separately and probably independently of age, weight, growth rate and vigor.

Transmission of resistance of fowls to *Shigella gallinarum* also appears to conform to Mendel's law. According to Lambert and Knox descendents of parents surviving an injection of *S. gallinarum* were 47.6 per cent more resistant than the offspring of parents that never withstood an attack of the disease. Hybrids of typhoid-surviving males and females not having had fowl typhoid were 26.2 per cent more resistent than the control. They attributed their results to multiple factor inheritance.

Roberts and Card also found that resistance and susceptibility of chicks to *Salmonella pullorum*, the causative organism of bacillary white diarrhea, is at least in part due to genetic factors. The selected stock was much more resistant than the unselected stock.

Irwin's work on the resistance of rats to injections of Danysz bacillus indicates that the transmission of immunity to this organism was largely genetic in nature.

One of the most conclusive evidences of inheritance of natural immunity is the work of Rich on the blood complement in guinea-pigs. "The complement is that constituent of the blood that guards the body against pathogenic organisms and tends in a way to supplement the combative activities of antitoxins, serums and vaccines." In his extensive experiments he found that it conformed to simple Mendelian inheritance acting as a simple recessive.

Another example of hereditary transmission of natural immunity is that of normal antitoxins present in the serum of many human beings and animals. Hirzfield demonstrated that these bodies were transmitted by the parents to their progeny according to Mendel's law. It is of interest to note here that

on the basis of our present knowledge of blood groups in humans, it appears that the inheritance of the four blood groups depends upon two pairs of Mendelian unit factors, "the specific agglutinogens being dominant to their respective iso-agglutinins."

Thus far very little experimental work has been done with the domesticated animals along the line of disease resistance. In crosses between common cattle and the zebu, which is immune to foot-and-mouth disease, anthrax, and highly resistant to Texas fever, favorable results are obtained. The zebu appears to transmit most of its favorable qualities to the F_1 offspring. With regard to subsequent generations, tick resistance appears to be carried over, although unfortunately the records are not satisfactory. Furthermore, other factors may enter in. Most of the data thus far have been taken under range conditions where greater prolificacy of the zebu may influence the apparent dominance of disease resistance. The fact that both male and female hybrids are fertile and of superior quality may be of great economic importance in the Southern cattle districts. Of course, the production of such hybrids would necessitate the establishment of central herds of zebu which would supply the demand for zebu bulls.

It may also be possible to develop breeds that would have the desirable conformation of the Northern breeds and the disease resistance of the zebu. Similar observations on the disease resistance of zebu hybrids were made by Johnson and Bancroft of Queensland and Pucci of Italy. Another hybrid that gives some promise of use in American agriculture is that obtained by crossing the bison and domestic cattle. It may be possible by long continued selection to combine the excellent qualities of the bison such as superior coat, greater hardiness, resistance to tick and insect infection, and the superior beef qualities of domestic cattle. However, more difficulties would be encountered due to the greater physical difference between the two animals and to the fact that the F_1 males are sterile.

The Nellore cattle may also play an important part in the development of disease resistant animals. According to observations made at the Philippine Station, the Nellore cattle are highly resistant to the strain of rinderpest, the mortality being insignificant. However, they are not entirely immune. The half bred Nellore cattle do not have the high degree of resistance to rinderpest possessed by the Nellore stock, but appear to have somewhat more resistance than the native stock.

In summary it is universally agreed by research workers that predisposition toward or resistance to a disease is transmitted in a Mendelian manner. There is still considerable disagreement as to the manner of inheritance. Since resistance is closely correlated with general physical and physiological factors it would appear to be unlikely that susceptibility to an infectious disease would be determined by any simple method of inheritance.

From the practical point of view the development of disease resistant races of domesticated animals may not be as easily accomplished as might appear upon first consideration. Since it is possible to select for but a few characters at a time, it is quite likely that while concentrating on disease resistance one may unfavorably affect qualities of utility. It is also probable that while immunity to one disease may be developed by hybridization and selections, susceptibility to other diseases even more serious may be developed

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A FEW-SEEDED BUD SPORT OF THE TOMATO

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FLOWERS OF NORMAL AND BUD-VARIANT TOMATO
Figure 11

Petals of bud variant, seen on the right, are narrower than those of the normal, on the left.

TWO bud-variant branches of tomato having nearly seedless fruits were found apparently originating independently on one plant of the variety Stone, and on one similar branch on a plant of the variety Globe. Both parent plants were growing in the field and were otherwise normal. The variant branches retained their distinctive characters when propagated vegetatively. They were bluer green, without the yellowish cast, and were less resinous than the normal branches. The smaller size of the resinous glandular hairs of the Globe bud variant, which was compared more closely with the normal, was very evident, and probably accounts for the difference in color. The variant also had fewer long trichomes and appeared less hairy (Figure 12). The leaflets of the variant were slightly narrower, the petioles more inclined upwards, the sepals longer and the petals narrower and more recurved than those of the normal plant (Figure 11).

Microscopic examination showed that the variant had a smaller proportion of apparently good pollen grains and ovules than the normal. Without hand

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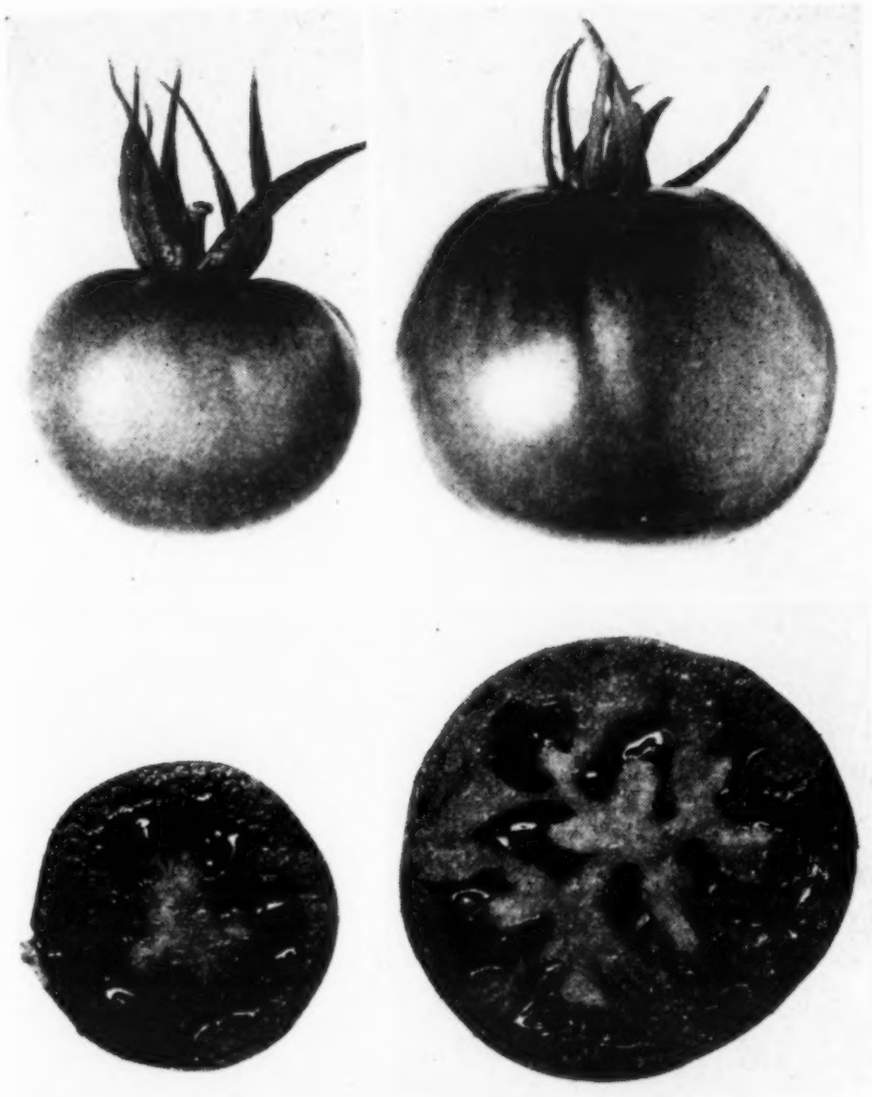
NORMAL AND BUD-VARIANT BRANCHES OF TOMATO

Figure 12

On the right is a normal branch of the variety Globe, on the left a bud variant which is less hairy. The variation is believed to be due to a somatic mutation of the epidermal layer.

pollination in the field, the normal branches set fruit abundantly, but the bud-variant branches very sparingly; in the greenhouse both normal and variant plants from cuttings set only a few very small seedless fruits. With hand pollination in the greenhouse the variant set fruit almost as readily as the normal, but the fruits of the variant were less than half the size of those of the normal plant and contained on the average only nine full-sized seeds as compared with 145 seeds in fruits of the normal (Figure 13). Fruits set on the normal ♀ pollinated by variant ♂ were of normal size and seed content, but fruits set on variant ♀ pollinated by normal ♂ were small and contained very few seeds. Hence the partial sterility of the bud variant seems to be largely due to defective female organs. Fruits of the variant had a dull surface similar to that of the peach tomato. In eating quality they were rather mealy, deficient in juice, and decidedly inferior to the normal. The somatic number of chromosomes of the variant was found by Mrs. Margaret M. Lesley to be 24, or the same as in the normal plant. From self-fertilization of the variant, 9 plants were raised, and from normal × variant, 4 plants. All of these were



FRUITS OF NORMAL AND OF FEW-SEEDED BUD VARIANT

Figure 13

Fruits of a bud-variant of tomato seen on the left are much less seedy and smaller than the normal fruits to the right.

normal without any characteristics of the variant. These breeding results indicate that the sub-epidermal or germinal layer is genetically unchanged. Apparently the bud variant originated from a mutation in a somatic cell of the epidermis; this appears to be an instance of a chimeral arrangement which involves partial sterility, similar to that of certain Pelargonium chimeras discussed by Chittenden[1]. Unfortunately this tomato variant was lost through an attack of "yellows" disease (western yellow blight).

Shoots of tomato affected with virus diseases such as shoestring mosaic are often unfruitful and show other abnormalities. Lighter green branches, similar to that described by Norton[2] on a plant of Acme, have appeared in our cultures. The chlorosis usually affects a single leaflet or half leaflet or a strip of stem, causing a more or less stunted development and often male sterility and unfruitfulness and, on account of its relatively common occurrence in several progenies in the past two seasons, is believed to be due to some form of virus disease. The variant branches of Globe did show slight mottling symptoms, but the normal branches were similarly affected. Moreover, the combination of characteristics of the variant does not correspond with the symptoms of any disease known to the writer. The variant was propagated by cuttings outdoors and in the greenhouse for more than two years without any evidence of infection of adjacent plants, so the cause of the variation was undoubtedly genetic.

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A Quarter-Century of Plant Genetics

A BIBLIOGRAPHICAL Monograph on Plant Genetics (Genic Analysis) 1900-1925, by Hajime Matsura, Professor of Botany in the Second Higher School of Sendai, Japan, has just been published by the Tokyo Imperial University. This encyclopedic work of 499 pages meets a long-felt need for a convenient reference manual covering with a fair degree of completeness the results of genetic investigations on plants, at least the flowering plants to which the present work is restricted. Forty-nine families, one hundred fifty genera, and over four hundred species are represented, which is a very impressive showing, especially when compared with the modest lists

of known Mendelian characters compiled by Hurst in the early years of the present century.

But the greatest value of this manograph, as a handy reference to the existing knowledge of genic analysis in plants, lies in the carefully prepared summaries which appear in Part I and which are for the most part fairly complete and accurate. It is unfortunate that in certain of the genera which have been outstanding in their contributions to the development of genetic concepts some of the important literature was not available to the compiler. A case in point is the genus *Matthiola*, in which the valuable contributions of Frost and Frost and Lesley are not represented. On the other hand, the reviews of *Lycopersicum*, *Nicotiana*, *Hordeum*, *Oryza*. *Pharbitis*, *Phaseolus* and *Zea*, to mention only a few, seem to include most of the important contributions. It is to be hoped, however, that a new edition of the monograph can be published in the not far distant future, in which will appear the more important works which are missing in the present volume. The present visit of the author to various foreign countries should assist materially in achieving this result.

Part II is the bibliography which is arranged by years from 1900 to 1925. The rapid spread of interest in genetics and the ever-increasing rate of publication of the results of experiments on genic analysis in plants are strikingly shown by this arrangement. Three indexes complete the volume, an index of subjects, one of authors, one of species and one of families.

Some will find the most interesting feature of the whole monograph in the brief but comprehensive foreword by Dr. K. Fujii. The writer reviews the outstanding events in the history of genetics, leading up to the present wealth of genetic data, the usefulness and significance of which is more or less obscured by the great diversity in the systems of symbols now in use and the diverse methods of representing genetic relationships.

It is to be hoped that this effort to bring together in one convenient reference work the great majority of the data on genic analysis in plants will result in more rapid progress toward a standardization of modes of representing genetic facts and theories. But, even if this hope should not be realized, the author is to be congratulated on having accomplished a very real service both to geneticists and to plant breeders, a service made possible only by long, painstaking endeavor, which merits the deep appreciation of all concerned. —*E. B. Babcock.*

Population Growth of Italy

THE Istitute centrale di statistica has published the following data pertaining to the growth of the population of Italy. In 1700, the total population of Italy was 16,477,000, with a density of 57.5 inhabitants per square kilometer of territory. In 1800, the population had increased to 18,125,000 inhabitants (63.2 per square kilometer); in 1825, to 19,721,000 (68.8 per square kilometer); in 1852, to 24,384,000 (85 per square kilometer); in 1872, to 26,801,000 (93 per square kilometer); in 1901, to 32,475,523 (103.3 per square kilometer). In 1928, the population was 41,173,000, which includes the inhabitants of the countries annexed since the war, and is equal to 132.8 inhabitants per square kilometer of territory.—*Jour. Amer. Med. Assoc.*, Nov. 30, 1929.

THE FERTILITY OF COLLEGE GRADUATES

II. A Comparison of the Average Number of Children Born to College Graduates with the Average Number of Children Born to Their Brothers and Male Cousins

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IN an earlier article I made a comparison between the average number of children born to "colonial wives" and to college graduates, showing that the "colonial wives", over a 220-year period, always had more children than the graduates. The "colonial wives" were probably of the same stock from which the college graduates came, but not necessarily of the same social class. In order to ascertain how it would be if they were all of the same family, an examination has been made of six New England genealogies, and the number of children born to college graduates and to their brothers and male cousins who did not go to college or other institution of higher learning has been noted. The following have been excluded: Men who were in any war, cousins whose brothers went to college, brothers and cousins who did not live to the age at graduation of their college relatives, and Mormons with plural wives. The colleges from which the men graduated number forty or so, and include most of the principal ones. The graduates scattered over the United States and some went to Canada. The period covered for all three groups—graduates, brothers and cousins—was 1790 to 1869, inclusive, those born within that period being taken. The genealogies were published from 1922 to 1927, inclusive.

It would seem that as the college graduate group could not contain many mental or physical defectives, and the group of brothers and cousins might, the results of this investigation would show that if the children of brothers and cousins averaged to equal or exceed the children of the graduates, the college course would be shown to be followed by decreased fertility. The massed results of the investigation are set out in Table I.

Two hundred and fifteen fathers of graduates and of brothers of graduates born between 1790 and 1890 had an average of 5.41 children. Two hundred and sixteen fathers of cousins born in the same period had an average of 4.98 children.*

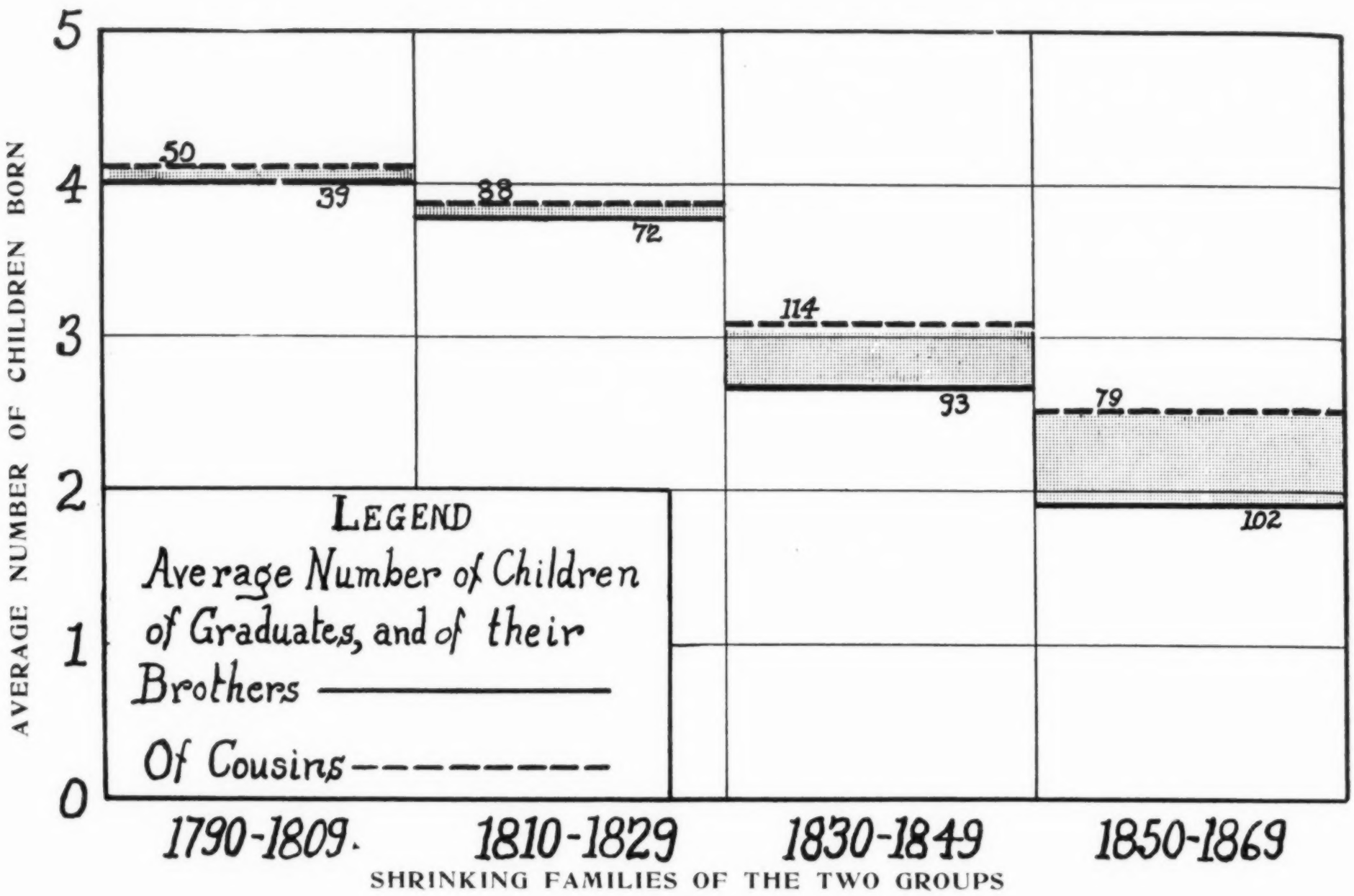
It will be seen that the graduates married the latest—a year and a half later than their brothers and two years and a half later than their cousins†—and had the least children per man, per married man and per married man having children.

For the sake of studying possible tendencies or changes, the figures have been divided into the first forty years and the second forty years, with the results shown in Table II.

Comparing the figures for the two periods above set out, we find that in each the graduates still averaged the fewest children, also that the age at marriage was advanced more among

*In "The Size of College Families," S. J. HOLMES, JOUR. OF HEREDITY, 407 (1924) is discussed the mathematical reason why families from which college students come are larger than ordinary families.

†In a survey of the graduates of many girls' colleges, it was found that they married on the average two years later than their sisters, cousins and friends who were educated in public or private schools, some of whom afterwards studied art or music, or traveled abroad. (Statistics of College and Non-College Women, 7 Am. Statistical Association, 1 (1900).



SHRINKING FAMILIES OF THE TWO GROUPS

Figure 14

The average fertility of college graduates and their brothers combined, over an 80-year period, was always less than that of their cousins, and the disparity progressively increased. The excessive declines in both groups in the two last periods were due to immigration.

the graduates than among their relatives. The most striking thing, however, is the relative drop in the average number of children in the three groups. That is, the graduates' children dropped 37 per cent, the brothers' 43 per cent, and the cousins' only 28 per cent. In other words, the brothers seem to be tending towards the same fertility as the graduates, and the spread between the fertility of families going in for higher education and those not going in for higher education seems to have increased. To put it in concrete form—suppose that there were two brothers, A and B, and that each had two sons during the first forty-year period. Suppose further that A is the kind of person who sends one of his sons to college, and that B is not. A would have 3.56 grandchildren through his son who went to college and 4.08 grandchildren through his son who did not go to college—a total of 7.64 grandchildren. And B would have 7.96. So A and B would have about the same number of grandchildren. If, however, we suppose A and B to have their four sons born during the second forty-year period, A would have but 4.54 grandchildren, while B would have 5.72.

A graph divided into twenty-year periods, showing the average number of children of graduates and their brothers combined and the average number of children of their cousins is shown in Figure 14. It will be seen not only that the graduates and their brothers always averaged less children than the cousins, but that the spread progressively increased. It will be remembered that a spread between social classes in England and Wales began about 1850 and gradually increased.*

It will also be noticed from Figure

*The curious reader will find a chart of it by R. M. MacIver in Dublin's *Population Problems* (1926), p. 290.

14 that in the second twenty-year period there was not much drop in either group below the averages of the first period, but that in the third and fourth periods the drop in both groups was more pronounced. This increased drop appears also if one plot graphs of the children of the Colonial wives and Yale graduates, dealt with in my earlier article to which I have referred above. It seems to me that this pronounced decrease in family size is due in part to the greater use of machinery and to immigration. Whether the increased spread just mentioned was also caused in part by the same things is a matter for speculation. My impression is that probably it was in part so caused, the population pressure created by immigration being transmitted through the colleges, academies, and the then recently inaugurated free high schools.

Men born in 1830 would graduate from college about 1852, and those born in 1869 about 1891. The figures for the period 1830-'69 are, therefore, comparable with Dr. Phillips' figures for Harvard and Yale graduates of the classes between 1850 and 1890, but it should be borne in mind that in the present study those who had been in any war were excluded. The comparison is set out in Table III.

An examination of the foregoing shows that although the Harvard and Yale graduates did not reproduce themselves during the period in question, the graduates of the families forming the subject of this study did reproduce, or nearly reproduce, themselves, and that the reason for it was not a greater number of children born per marriage, but a greater percentage of marriages. But, of course, as to percentage of marriages the basis is different, the Harvard and Yale averages being per class member.

For those who are interested to study figures more minutely, Table IV, dividing the period into decades is set out.

From the above, it appears that the brothers started out with the most children of all and ended with the least, and that the transition came when the major part of the sons of a family began going to college, thus leaving a relatively small number to carry those who may have been deficient in survival qualities. But there may be more to it than that. The brothers may gradually have drifted into occupations more nearly comparable with those of the graduates.

"Success" of the Three Classes

In an effort to see how such of the graduates, brothers and cousins as were deceased came out financially, I have ascertained from the Probate Courts the appraised value of all the estates which I could locate. The results are set forth in Table V. These appraisals are for the gross estates and make no deductions for debts and, therefore, may not give an altogether fair picture. Of course, they do not disclose relative earnings, or necessarily savings out of earnings, as the money in any estate may have come, in part at least, by inheritance, and there may have been gifts before death, etc. As a brother could not be an only son, and a graduate might be, the graduates are given in two columns, in the first of which only sons, who might be sole heirs, are omitted, and in the second included. As no count was kept of sisters, this cannot be claimed to be very scientific. The cousins' column does not exclude only sons. It seems to me that column 1 is the one to compare with the brothers, and column 2 with the cousins. The period covered is the 100-year period from 1790 to 1890. All the work which forms the basis for this article was originally done for this 100-year period, but as the last two decades would not show completed families, they have been omitted throughout except in this table as to estates, where the reasons for excluding them are not quite so strong.

An examination of this table will show that the brothers came out ahead. If the comparison be made decade by decade between the graduates, only sons

omitted, and the brothers, the comparison which I have suggested as fairest, the difference is very pronounced. On the other hand, a comparison between the graduates, only sons included, and the cousins shows the graduates somewhat ahead. A merely casual inspection of the figures does not at once reveal how important the only sons are among the graduates. The estates of the eleven only sons averaged about $113,000 apiece—nearly three times as much as the $40,000 of the twenty-one graduates who were not only sons. In other words, it looks as though inheritances may have been important. Of course, the whole number of estates is not very great for any of the columns. In order to get a broader average, the estates of the brothers and cousins can be combined, giving the result that sixty-eight estates of non-college men averaged $67,102.91 as against $65,380.03 for the thirty-two graduates (including only sons); that is, they seem to have come out about alike, though the college men average a little less than their relatives. The only millionaire was a cousin.*

Table I. Marriage Statistics of B----r Family. 1790-1869

	Graduates	Brothers	Cousins
Number in Group	160	146	331
Number Married	145	129	311
Number Unmarried	15	17	20
No. Married Having Children	130	113	280
No. Married Having No Children	15	16	31
Number of Children Born	417	454	1101
Average Number of Children Born Per Man	2.61	3.11	3.33
Average Number of Children Born Per Married Man	2.88	3.52	3.54
Average Number of Children Born Per Married Man Having Children	3.21	4.02	3.93
Average Age at Marriage	29.40	27.87	26.82
Per Cent. of Group Married	91%	88%	94%
Per Cent. of Group Unmarried	9%	12%	6%
Per Cent. of Married Having Children	90%	88%	90%
Per Cent. of Married Having No Children	10%	12%	10%
Average Age at Graduation	22.32		

Table II. Marriage Statistics for Graduates and the Brothers and Cousins in the B----r Family, for periods 1790-1829 and 1830-1869.

1790 - 1829 inclusive	Graduates	Brothers	Cousins
Number in Group	45	66	138
Number Married	42	62	132
Number Unmarried	3	4	6
Number Married having Children	40	57	121
Number Married having No Children	2	5	11
Number of Children Born	160	269	549
Average Number of Children Born Per Man	3.56	4.08	3.98
Average No. of Children Born Per Married Man	3.81	4.34	4.16
Average Number of Children Born Per Married Man Having Children	4.00	4.72	4.54
Average Age at Marriage	28.54	27.79	26.54
Per Cent. of Group Married	93%	94%	96%
Per Cent. of Group Unmarried	7%	6%	4%
Per Cent. of Married Having Children	95%	92%	92%
Per Cent. of Married Having No Children	5%	8%	8%
Average Age at Graduation	21.96		
1830 - 1869 inclusive			
Number in Group	115	80	193
Number Married	103	67	179
Number Unmarried	12	13	14
Number Married having Children	90	56	159
Number Married having No Children	13	11	20
Number of Children Born	257	185	552
Average Number of Children Born Per Man	2.23	2.31	2.86
Average Number of Children Born Per Married Man	2.50	2.76	3.08
Average Number of Children Born Per Married Man Having Children	2.86	3.30	3.47
Average Age at Marriage	29.73	27.93	27.01
Per Cent. of Group Married	90%	84%	93%
Per Cent. of Group Unmarried	10%	16%	7%
Per Cent. of Married Having Children	87%	84%	89%
Per Cent. of Married Having No Children	13%	16%	11%
Average Age at Graduation	22.46		

Table III. Comparison of Harvard and Yale Graduates with graduate in B----r Family.

	Harvard Classes 1850-'90	Yale Classes 1850-'90	Graduates of B---r, etc. Families. Classes about 1852-'91
% Married	74%	78%	90%
Interval between graduation and marriage	8.7	8	7.27
Average number of children born per capita per married graduate	2.51	2.57	2.50
Average number of children born per capita per graduate	1.71	1.99	2.23
Per Cent of Childless Marriages	21%	19.1%	13%
Per Cent of Graduates Having No Children	42%	39.9%	21.7%

Table IV. Size of B----r, etc. Families.

Decade of births of graduates, brothers and cousins	No. of graduates	No. of children	Aver. no. of children born per capita per graduate	No. of brothers	No. of children	Aver. no. of children born per capita per brother	No. of Male cousins	No. of children	Aver. no. of children born per capita per male cousin
1790-1799	7	26	3.71	7	40	5.71	18	73	4.06
1800-1809	13	41	3.15	12	51	4.25	32	135	4.22
1810-1819	11	36	3.27	21	102	4.86	40	146	3.65
1820-1829	14	57	4.07	26	76	2.92	48	195	4.06
1830-1839	18	47	2.61	25	93	3.72	57	170	2.98
1840-1849	33	79	2.40	17	29	1.71	57	182	3.19
1850-1859	38	90	2.37	18	33	1.83	41	108	2.63
1860-1869	26	41	1.58	20	30	1.50	38	92	2.42
Totals	160	417	2.61	146	454	3.11	331	1101	3.33

Table V.-Average Appraised Value of Estates of Graduates, Brothers and Cousins of B----r, etc. families, according to figures obtained from Registries of Probate, - arranged according to decade of death

Decade	Estates of Graduates (only sons omitted)	Estates of Graduates (only sons included)	Estates of Brothers	Estates of Cousins
1820-29	----------	----------	----------	(2) 2,439.18
1830-39	(1) 100.00	(1) 100.00	----------	(1) 1,507.00
1840-49	----------	(1) 4,000.00	----------	(1) 1,189.34
1850-59	(3)69,809.95	(3) 69,809.95	----------	(1) 4,420.15
1860-69	----------	----------	(2) 110,755.72	(2) 4,750.76
1870-79	(2)30,854.13	(3)120,035.72	----------	(8) 153,259.11
1880-89	(1) 8,824.65	(2) 7,912.33	(6) 54,771.19	(7) 32,331.79
1890-99	(4)23,138.30	(6) 58,032.06	(4) 44,246.22	(5) 7,907.02
1900-09	(2)22,511.63	(4) 28,218.64	(5) 14,528.79	(6) 83,120.50
1910-19	(5)71,321.48	(9)101,103.00	(9) 136,844.30	(7) 55,442.00
1920-28	(3)25,089.33	(3) 25,089.33	(1) 141,141.32	(1) 360.35
Grand Average	(21)40,453.08	(32)65,380.03	(27) 80,458.05	(41) 58,307.41

*In a statement prepared for the faculty by Dr. Harold F. Clark, Professor of Education at Teachers' College, Columbia University, and made public in March, 1929, appears the following:

"Why has no one compared the incomes of brothers of equal ability who went to school different lengths of time? What would you expect the result to be? We have been making such a study in a preliminary fashion. Our preliminary results show that

To sum up: The college graduates over an eighty-year period have consistently had less children than their cousins, who did not go to an institution of higher learning; they have also had less children than their brothers, though in the latter half of the period there was a tendency for the brothers' children to average down to the graduates', or lower; that the cousins always married earliest, on the average, the brothers next, and the graduates last.

the longer one goes to school *above a certain minimum,* the less is his income. The results rather consistently show that the man who went to school longer had a smaller income than his brother who did not go so long."

World's End

THE END OF A WORLD. By CLAUDE ANET. Translated from the French by Jeffery E. Jeffery. Pp. 278. With many drawings from the caves of Eyzies de Tanyac. Price $3.00. Alfred A. Knopf, New York, 1927.

Astronomers tell us that the world will spin on for several million years yet—for all practical purposes an eternity. While the physical world goes on, biological and human worlds have been ending since the dawn of history—and for millions of years before. The world of many tribes of Indians ended shortly after October, 1492—among them the world of the Incas, one of the most remarkable that man had achieved—toppled into oblivion by a handful of gold-crazy adventurers who had little to offer in return for what was destroyed. The gold which they obtained with torture, fire and sword, helped to bring about the downfall of Spain, and to build another world—that of the Anglo-Saxon, which some believe is even now preparing to topple to its end.

The oldest human worlds of which we have any real record date from the stone ages, and the fragments that have come down to us leave many parts of the picture blank. Even the excellent reconstructions of the archeologists are not all that could be desired in the way of flesh-and-blood vividness. Stone axes, however beautifully made, and chips of pottery and bone, however valuable for contrversial purposes, hardly live and breathe. With a background of the pictures on the walls of caves in Southern France, in the valley of the Vezere, Anet has attempted to clothe the bare bones and re-haft the stone axes, and to make the incidents of twelve thousand years ago live again.

With the simple but impressive properties* which the caves have preserved, he tells the story of the last days of the People of the Bear, and of the end of their world in the face of a cruder but more adaptable culture. The story is vividly told and the archaeological details seem accurately enough drawn to give a fairly well proportioned picture of this tragedy of a hundred and twenty centuries ago. The illustrations are all from the caves and are excellent. They make up in reality for anything that may have been lost in reconstructing the story of Nô, the huntsman-artist, whose attempt to stave off the inevitable by domestication of the horse ended in frustration and death.

—*R. C. C.*

*Drawings of rhinoceros, mammoth, horse, bear, bison reindeer; a piece of shell identified as an East Indian species; carvings in bone and stone—"a race, however, which was the first to leave, as an everlasting trace of its passage, works whose beauty can still stir our emotions."

A COMB-INHIBITING GENE

An Inhibitor of the Development of the Pea and Walnut Combs in Domestic Fowl

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THE comb of the domestic fowl has four chief forms: the single, rose, pea and walnut combs. The most recessive form is the single comb. Both the pea and rose combs are dependent on one dominant gene each and independent from one another. According to the decimal system of A. S. Serebrovsky* these genes are designated as *weque* (pea) and *wene* (rose). The walnut comb develops in individuals which have both the *weque* and *wene* genes. At present we are interested only in the gene *weque* and therefore we shall everywhere indicate only the presence of absence of it, without describing the form of comb.

During the last five years the following progeny have been obtained (Table 1) from different matings at this station involving the gene *weque*.

TABLE I

Type of mating	*Offspring*	
	weque pea	*aweque not pea*
Weque (heterozygous) × *weque* (hetero)	352	126
Expected	358.5	119.5
Weque (het) × *aweque*	950	1,282
Expected	1,116	1,116

The presence or absence of *weque* in all individuals cited here was determined exclusively by the phenotype. Classification of comb form was made on one-day-old chicks. The four classes rose, walnut, pea, single were separated without any doubt at that time. All individuals with lateral rows of papillae beside the blade of the comb were classed as pea comb.

The matings of heterozygous individuals (Table 1) showed a ratio almost exactly corresponding to the expected one. In the matings of heterozygous individuals with recessive ones there was obtained a definite preponderance of *aweque* forms. Instead of a ratio 1116: 1116±23.6, a ratio of 950: 1282 was found. The difference is equal to 7 times the standard error, and is, therefore, quite significant. If we had not at our disposal the data of the second generation, we could attribute the preponderance of *aweque* forms in the backcross either to the incomplete expression of the *weque* gene or to errors in classification. However, both these explanations are inadequate, because the progeny of all the matings was classified by the same person. Evidently, the preponderance of *aweque* forms depends wholly on the parents of the *aweque* types. It is quite probable that in some of the *aweque* birds there was present a gene (or several genes) which inhibited the manifestation of the gene *weque*. This idea is confirmed by the examination of the relations between *weque* and *aweque* forms in separate matings. We have selected for illustration all the *aweque* cocks, which were mated with heterozygous *weque* hens, and which gave more than 40 chicks.

TABLE II

Cock	713	gave	19	*weque*	and 20	*aweque*
Cock	745	gave	29	*weque*	and 33	*aweque*
Cock	4.219	gave	24	*weque*	and 18	*aweque*
Cock	5,202	gave	47	*weque*	and 40	*aweque*
Cock	716†	gave	45	*weque*	and 67	*aweque*
Cock	755†	gave	15	*weque*	and 43	*aweque*

*Serebrovsky's decimal system of genetic nomenclature is described in *Journal of Heredity* 19:511-519. 1928.

†Pure bred Minorca with large single comb.

Each of the first four cocks gave a good ratio approximating 1:1: the last two gave a considerable preponderance of *aweque* forms. The ratio observed in the progeny of the last cock very nearly corresponds with the 3::1 ratio expected if it possessed in heterozygous state a dominant inhibitor of the gene *weque*.

The preponderance of *aweque* is also seen in the matings of the offspring of cock 716. These individuals possessed single and rose combs and were mated with *weque* heterozygotes. From all such matings were obtained 85 chicks, out of which only 28 were *weque* in appearance; the remaining 67 were described as *aweque*. Even the grandchildren of the cock 716 (*aweque* in appearance) when mated with *weque* heterozygotes gave 42 *weque* and 96 *aweque* chicks. A particularly sharp preponderance of *aweque* was obtained in the mating of the descendants of the son of cock 716—the cock 10557. His two daughters gave with a *weque* (het.) cock 10429 a ratio of 6:30. It is interesting to note that the cock 10557 itself gave also a preponderance of *aweque* individuals (13 *weque* and 26 *aweque*).*

In 1927 we acquired 3 single-combed Black Minorca hens registered as No. 746, 747 and 748. During 1927 and 1928 they were mated with cocks 8777 and 11333, both of which had walnut combs and were heterozygous for the genes *wene* and *weque*. From these matings were obtained the following offspring.†

The hens 746 and 747 gave a definite preponderance of *aweque* forms. Instead of the ratio 30:30±3.87 there was obtained a ratio of 16:44, differing from the first one by 3.62 times the error. However, the ratio obtained almost exactly coincides with the ratio 1:3, which ought to be obtained if the hens were heterozygous for a dominant inhibitor of *weque*.

For the purpose of verifying the correctness of this explanation, six hens were tested which were *aweque* in appearance, originating from matings 8777×746 and 8777×747. Some of the hens with *aweque* combs should possess the gene *weque*, which could not be manifested because of the presence of the inhibitor obtained from their mother. The six hens were mated with *aweque* cocks. The results were as follows:

TABLE IV

Mating	*Progeny*	
	weque	*aweque*
11775×12117	0	10
11523×12117	0	1
11790×11429	0	21
11550×11450	0	3
11960×11604	0	20
10274×11841	0	24
11790×11984	3	10

Of five hens sufficiently tested, four did not give a single *weque* descendent and one gave 13 chicks, 3 of which turned out to be *weque*. According to the theoretical calculation, there were to be expected among the six hens 1.7 individuals which ought to give *weque* and *aweque* chicks in a ratio of 1:3. Actually there was found one individual, which being *aweque* in appear-

*The offspring of cock 755 could not be analyzed, because it was mated only in 1928.

†**TABLE III**

Matings			*Offspring*					
			weque		*aweque*		*Total*	*Total*
Walnut ♂	×	*single ♀*	*Pea*	*Walnut*	*Single*	*Rose*	*weque*	*aweque*
8,777	×	746	4	3	10	7	7	17
8,777	×	747	5	4	6	21	9	27
							16	***44***
8,777	×	748	4	4	0	5	8	5
11,333	×	748	5	1	7	7	6	14
							14	***19***

ance, when mated with a similar cock, gave exactly one-quarter of the offspring with *weque*.

The cock 11790, which gave *weque* chicks with hen 11984, is undoubtedly really *aweque*. With other *aweque* hens he gave 61 chicks, out of which not a single one was *weque*.

According to our opinion, the hen 11984 proves the real existence of an inhibitor of *weque*, which ought to be called (according to the decimal system of A. S. Serebrovsky) *wequeke* gene.

A Prize for Essay on the Falling Birth-Rate

IN response to a recent prize offered by the Eugenics Research Association, essays submitted on the birth-death ratio in various countries have shown that the net fecundity has been falling for the last forty years in different European countries.

This Association now (September, 1929)) offers a new prize of $3,500 for the best essay upon the causes of this decline, with especial reference to Europeans and persons of European stock.

The treatment should be historical, should include an analysis of studies already made upon the subject, and should lay stress upon the phenomenon in peoples of Nordic, or chiefly Nordic origin in all parts of the world. Preference will be given to essays which are based upon objective studies rather than expressions of opinion.

The contest is open to the world, and the essays may be written in the English, German or French languages.

Essays must not be signed, but each must be identified by a motto, and accompanied by a sealed envelope containing the name and address of the author.

The Association reserves the right of publication of essays submitted.

The essays in competition for this prize are to be mailed to the Eugenics Research Association, Cold Spring Harbor, N. Y., U. S. A. They should be posted so as to reach their destination not later than June 1st, 1930.

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